Climate Change:

Insights from Science, Implications for Responses

The 2013 Governor's Conference on Energy & the Environment

Rosina Bierbaum
School of Natural Resources & Environment,
& School of Public Health
University of Michigan

2013 Kentucky GOVERNOR'S CONFERENCE on ENERGY & THE ENVIRONMENT

Outline of the Presentation:

I. Climate change is occurring and is due to human influence

II. Impacts are already being felt

III. What does the future portend?

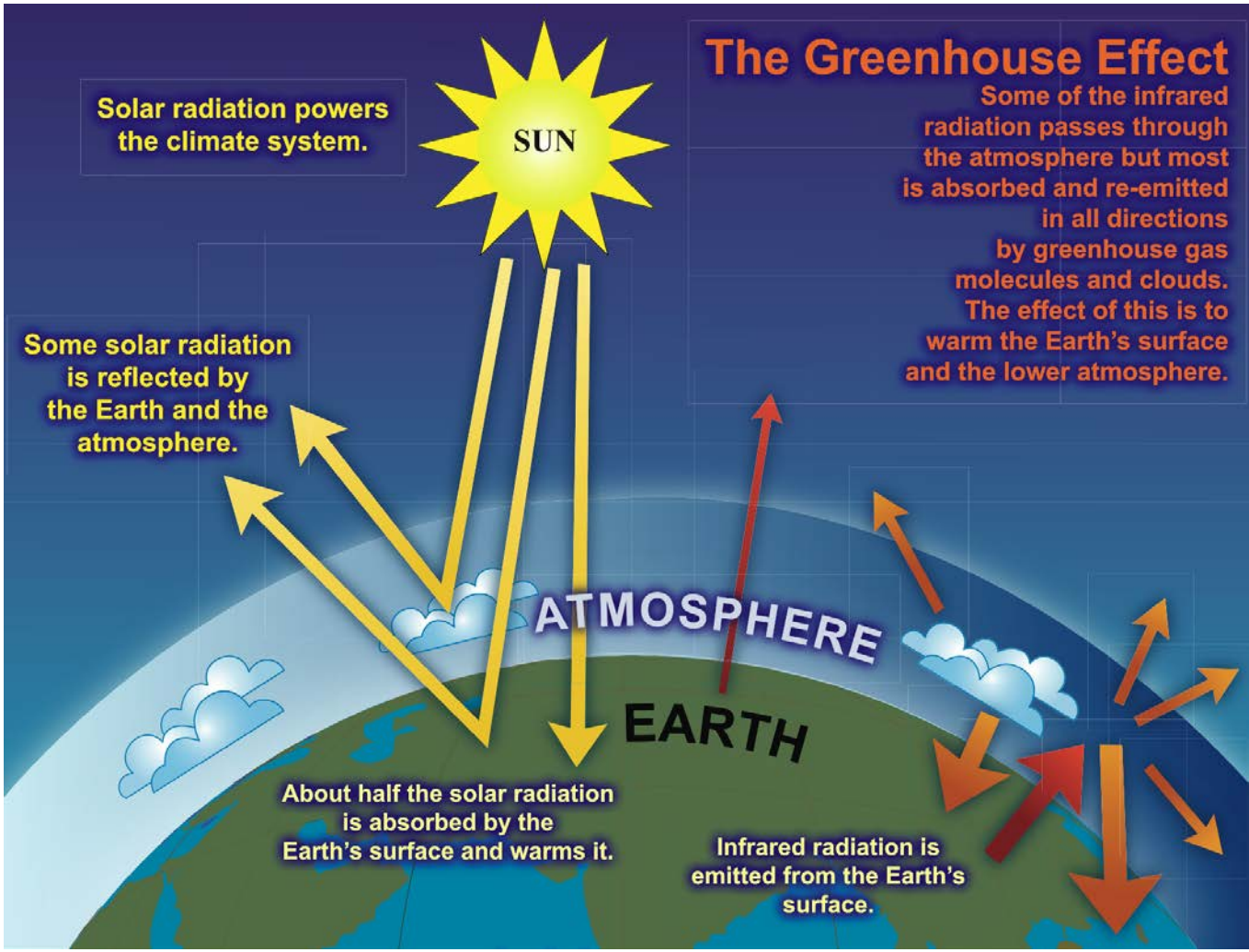
IV. Ways forward

I. Climate change is occurring and is due to human influence

The Greenhouse Effect

The natural greenhouse effect increases surface temperatures by about 60°C.

Increasing greenhouse gas concentrations increases surface temperatures.



The theory of climate change is not new…

THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

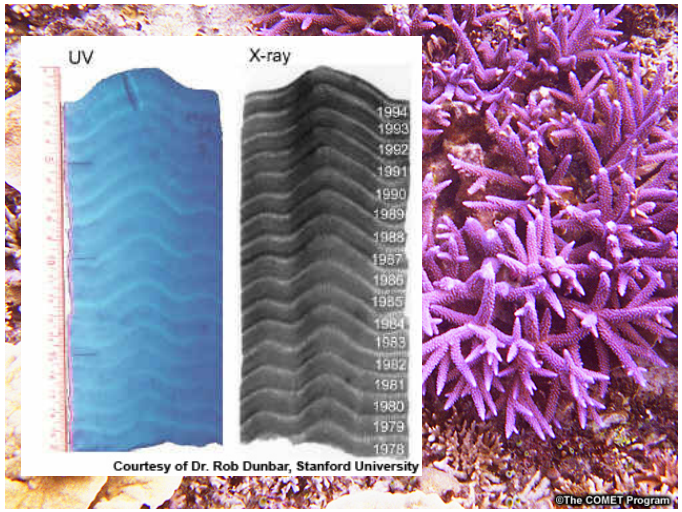
XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* *By* Prof. SVANTE ARRHENIUS *.

I. *Introduction : Observations of* Langley *on Atmospherical Absorption.*

In 1896, Arrhenius projected that carbon dioxide (CO_2) emissions from the burning of fossil fuels would raise surface temperature; doubling CO_2 could lead to >4 °C temperature increase

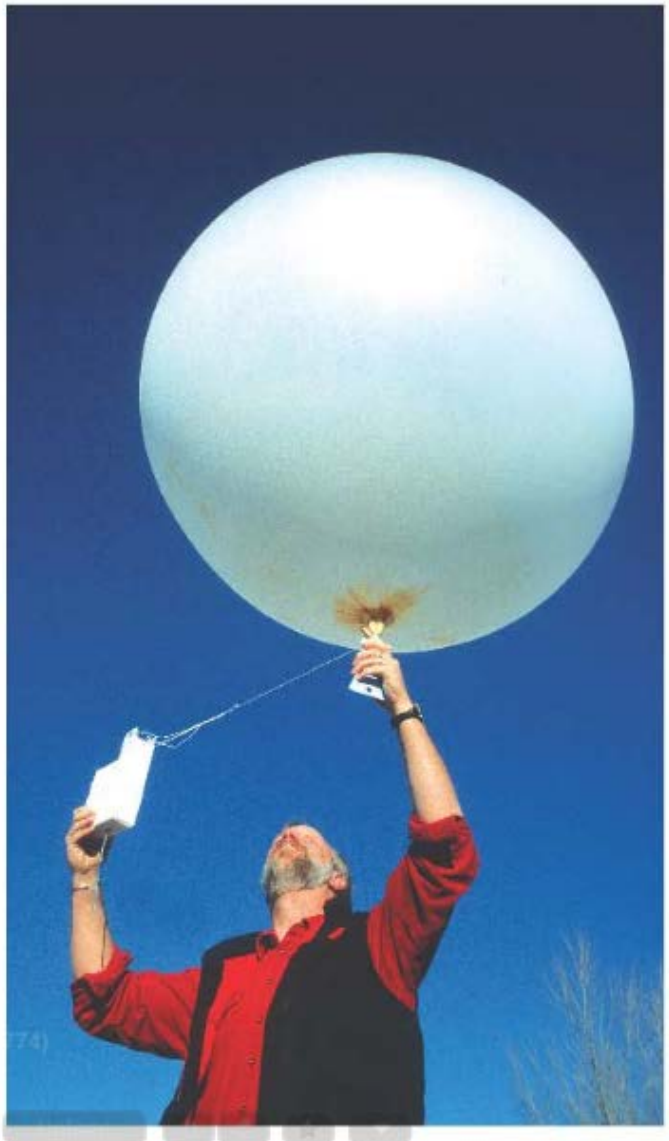
We can decipher past climate

By examining tree rings, ice cores, fossils, and corals, scientists can put together a robust record of previous past climates over centuries

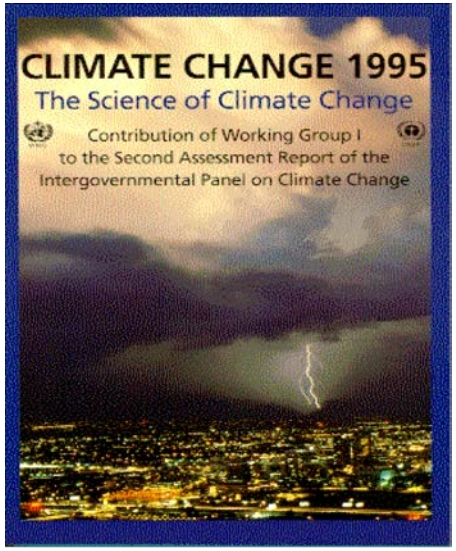


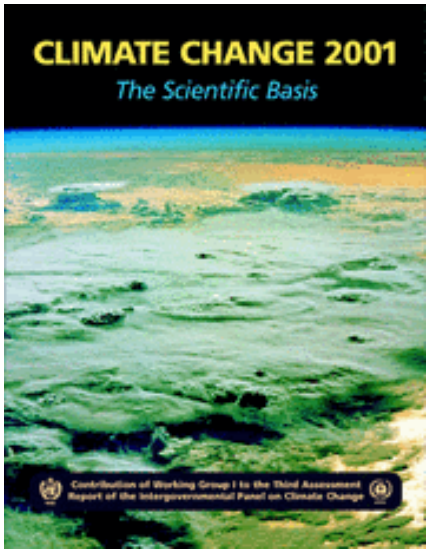
We are observing Current Climate

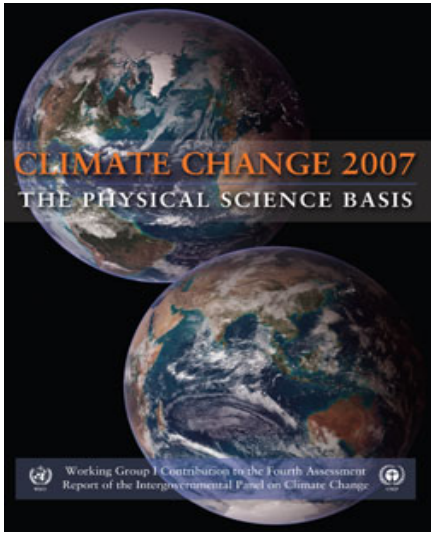
Thousands of land, air, & ocean measurements are made
of temperature, precipitation, & sea surface



Over the last 20 years, scientific certainty has been increasing







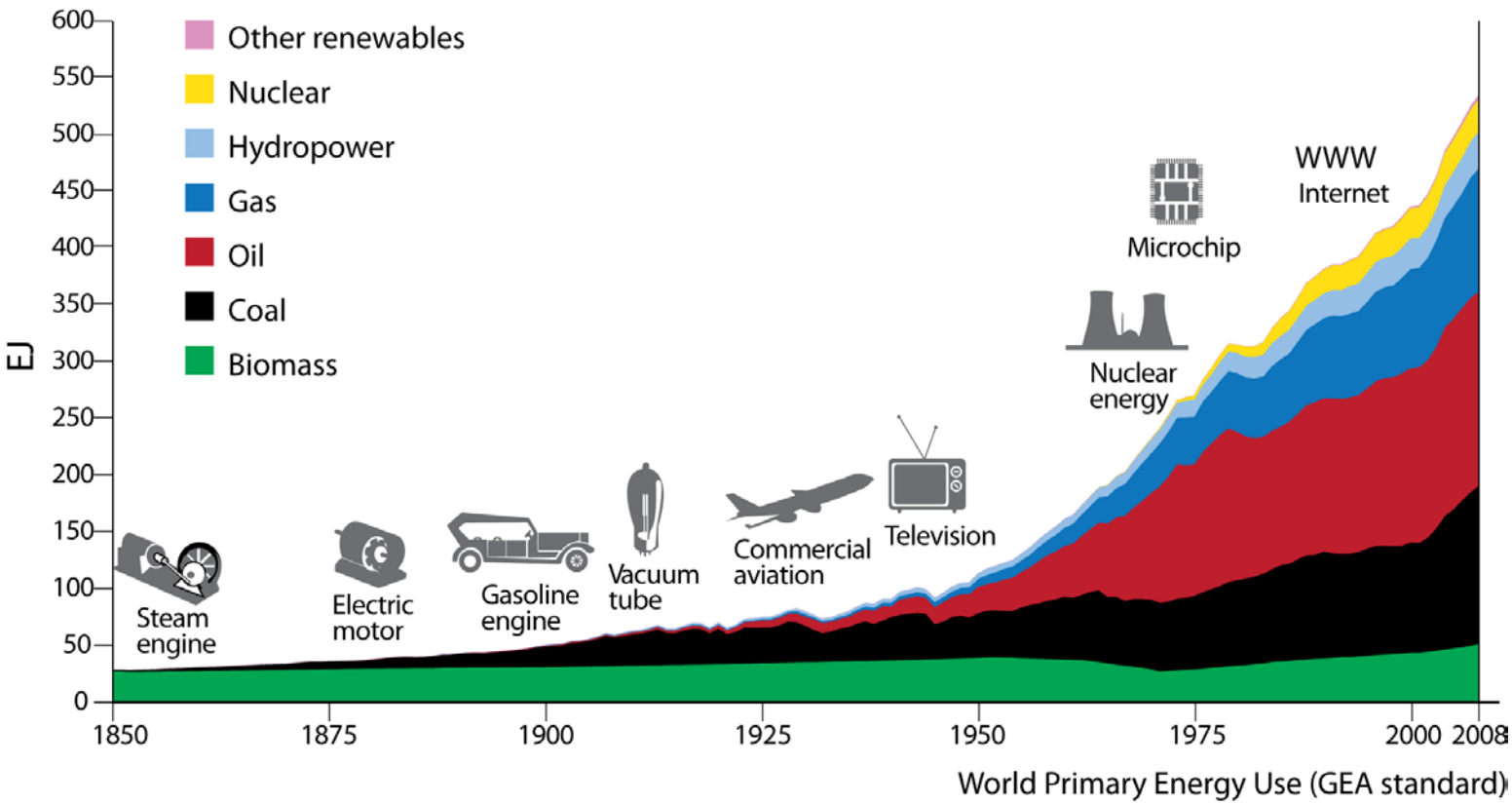
"The balance of evidence suggests a discernible human influence on global climate"

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities"

"Warming of the climate system is unequivocal…. Most of the observed increase since the mid-20th century is very likely [>90%] due to the observed increase in anthropogenic greenhouse gas concentrations."

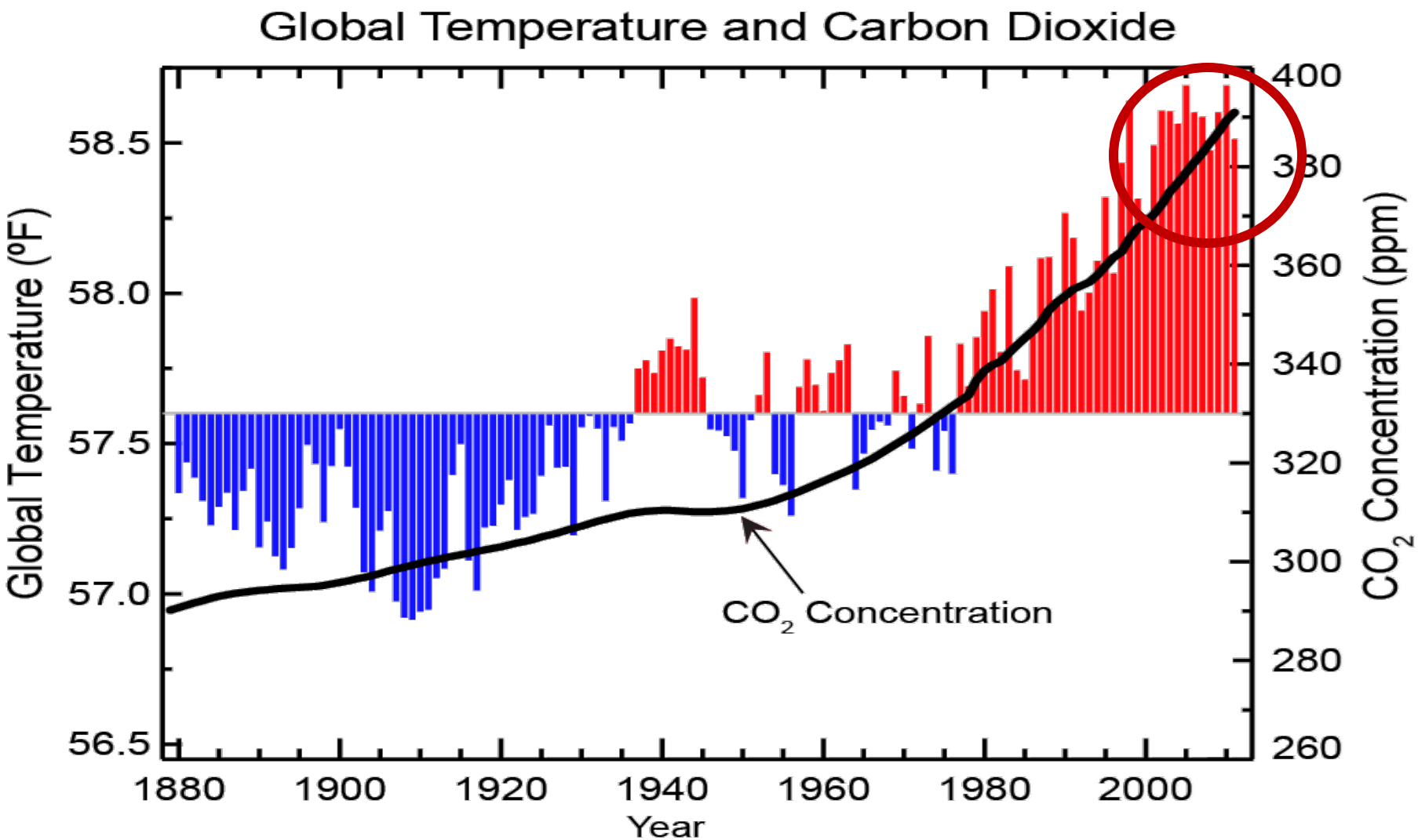
World primary energy use since 1850

still largely carbon based



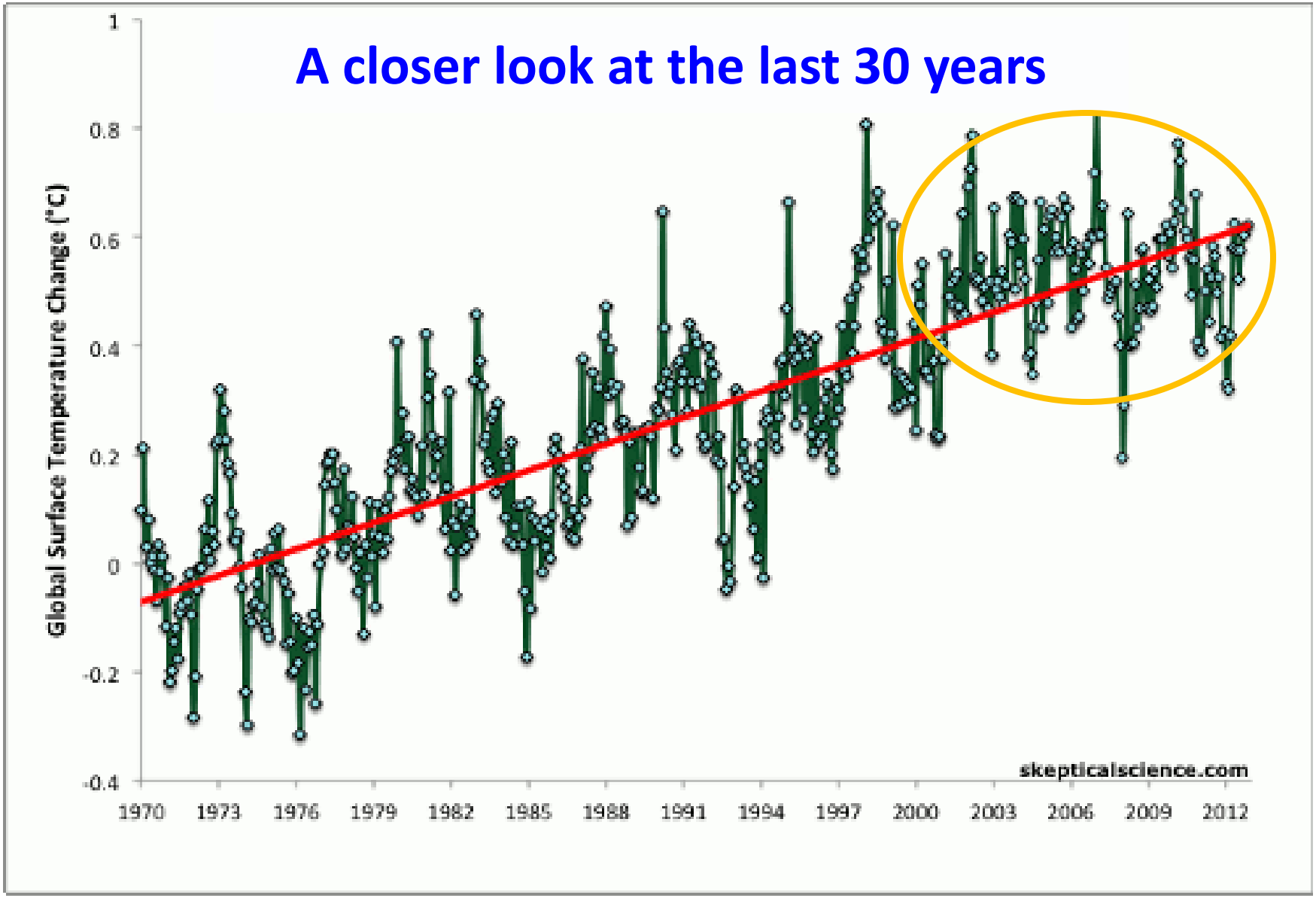
Source: Grubler et al, 2012

Carbon Dioxide and Human Activity



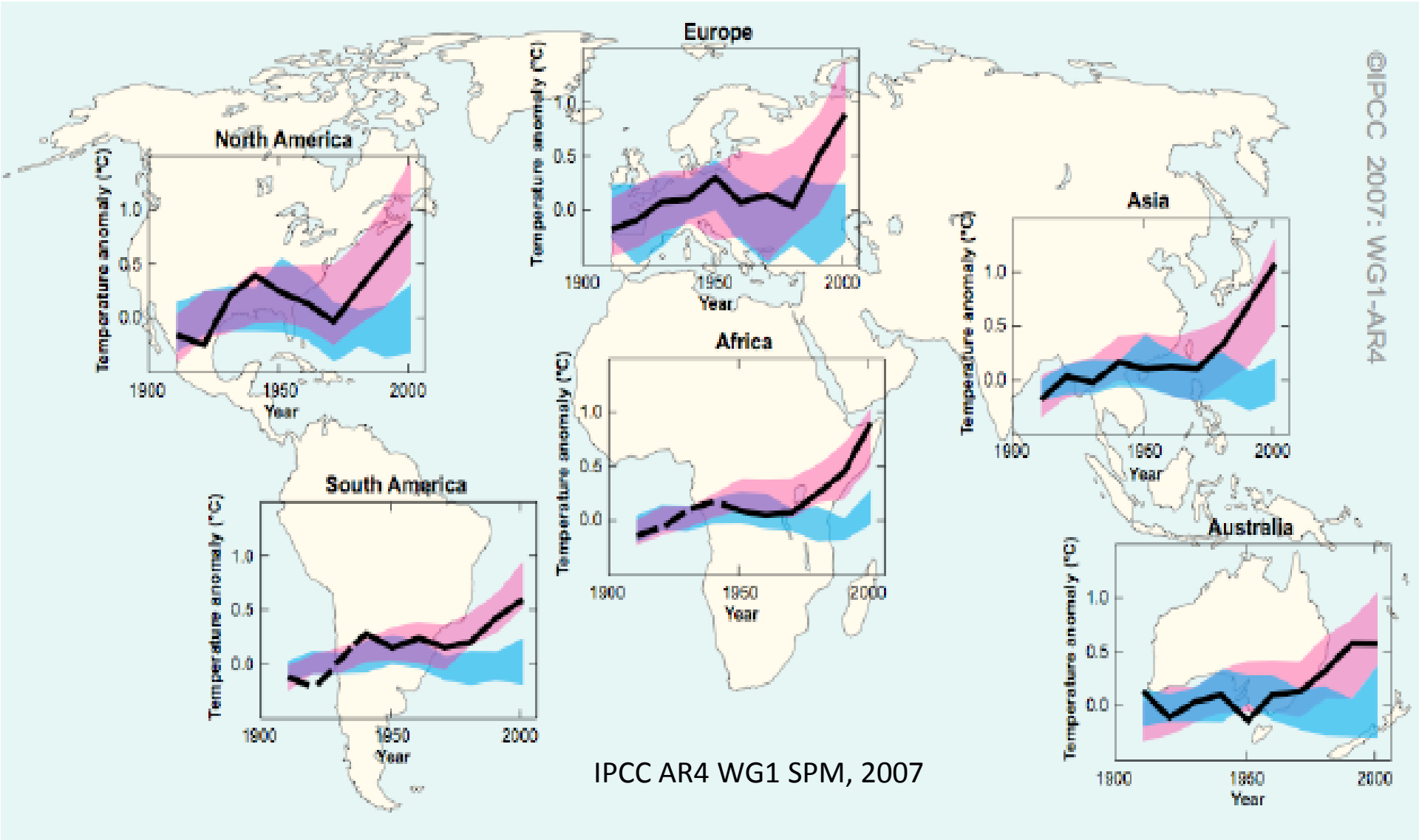
There is a close correlation between CO2 and temperature that has been verified through many lines of research . This graph shows the relationship of temperature and CO2 over the last 130 years

A closer look at the last 30 years



Scientific consensus:

Observed Change in Temperatures Match Computer Projections

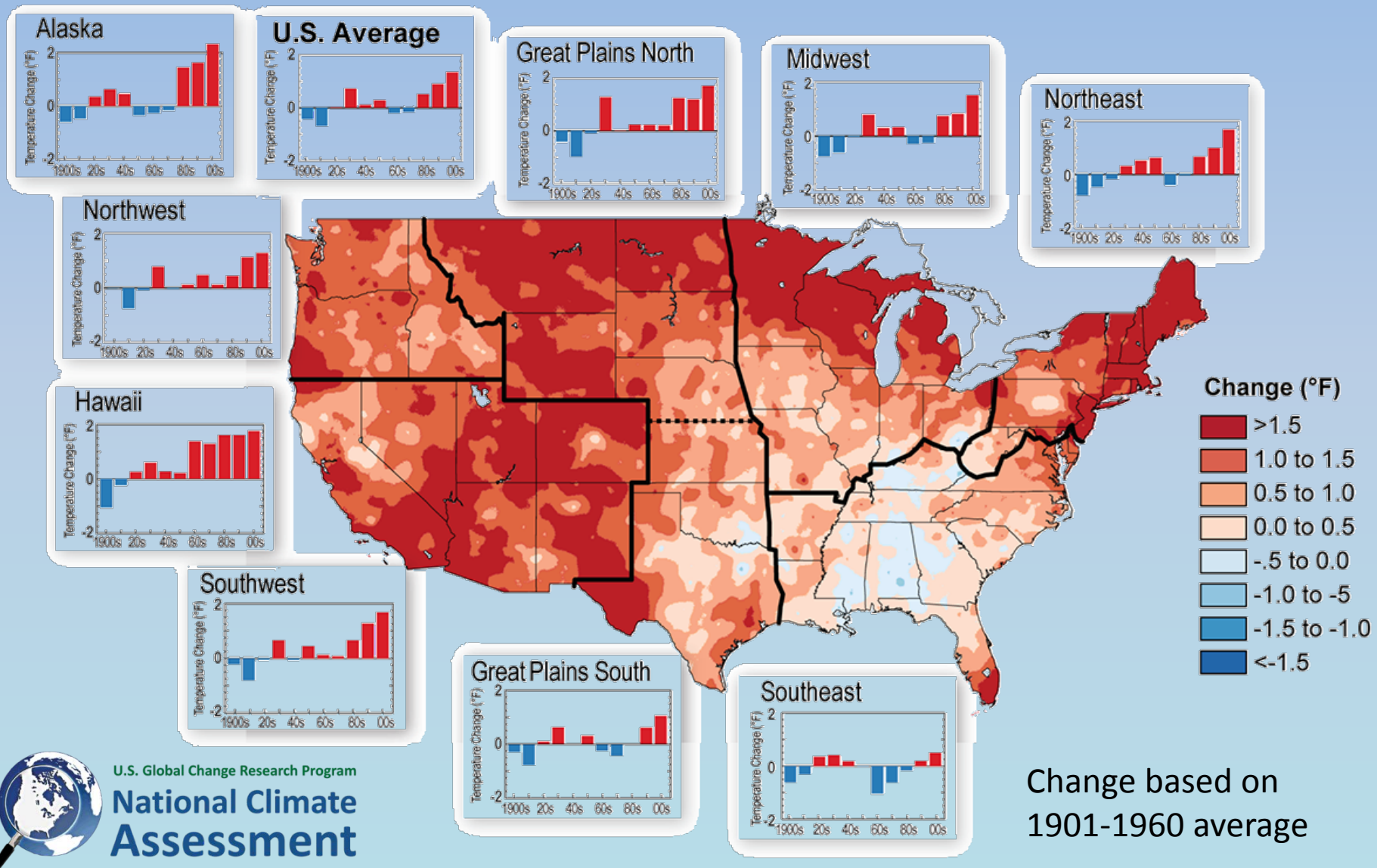


IPCC AR4 WG1 SPM, 2007

Black lines are decadally averaged observations. Blue bands are computer models with natural forcings only. Pink bands are computer models with human + natural forcings.

Change is also apparent across the U.S.

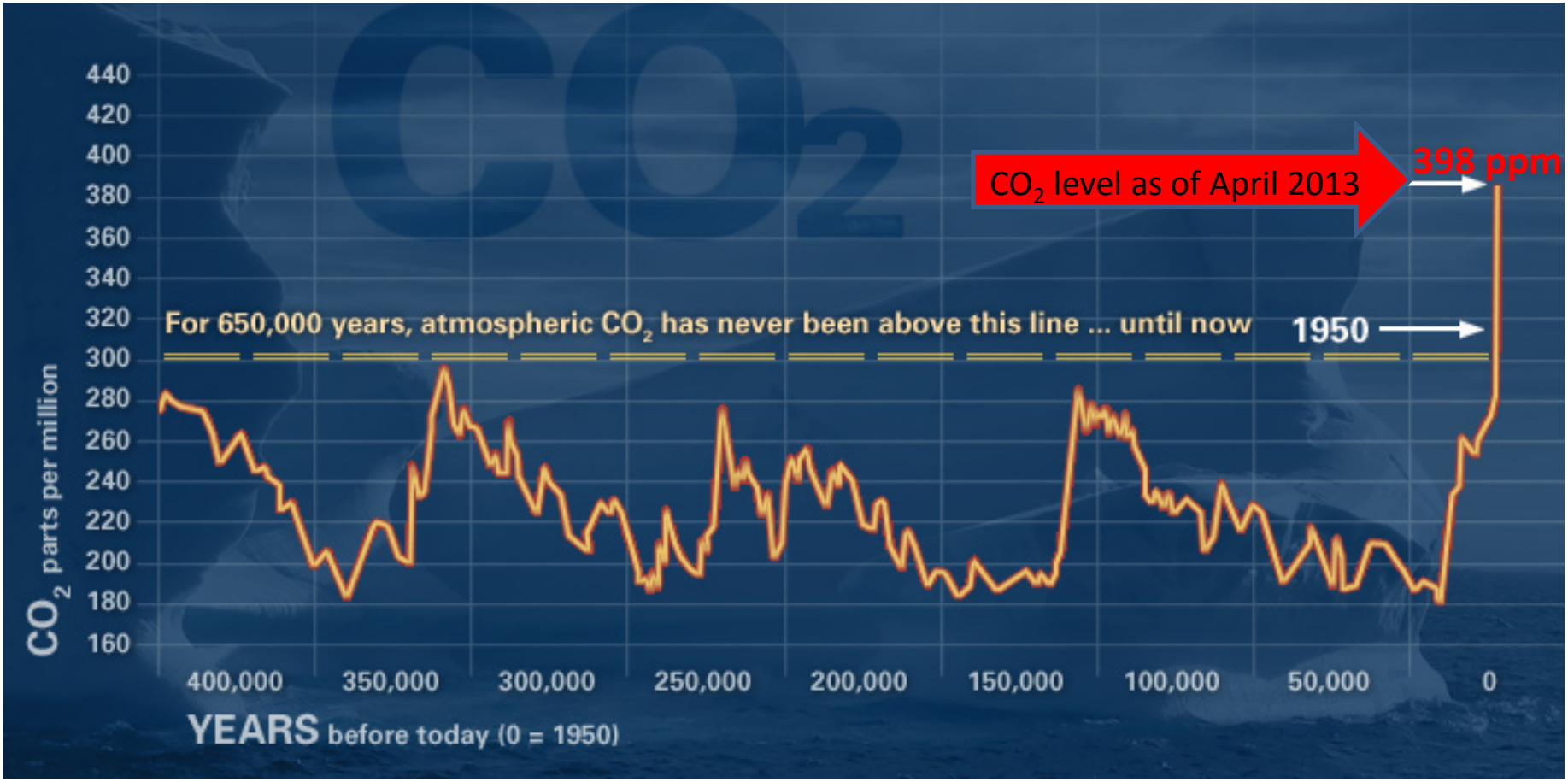
Observed U.S. Temperature Change



U.S. Global Change Research Program
National Climate Assessment

Change based on 1901-1960 average

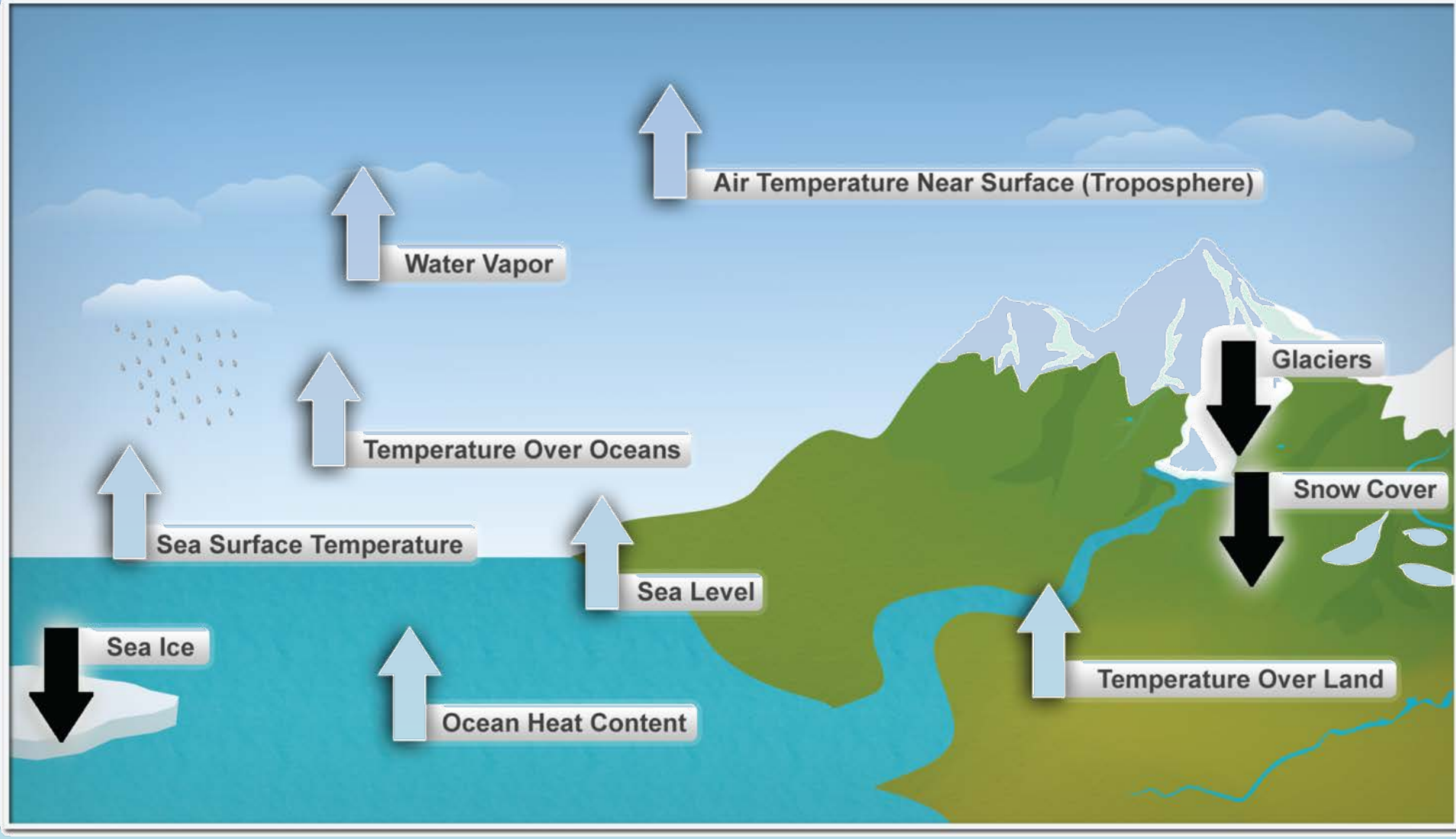
Atmospheric CO_2 is now higher than it's been for 650, 000 years and increasing rapidly



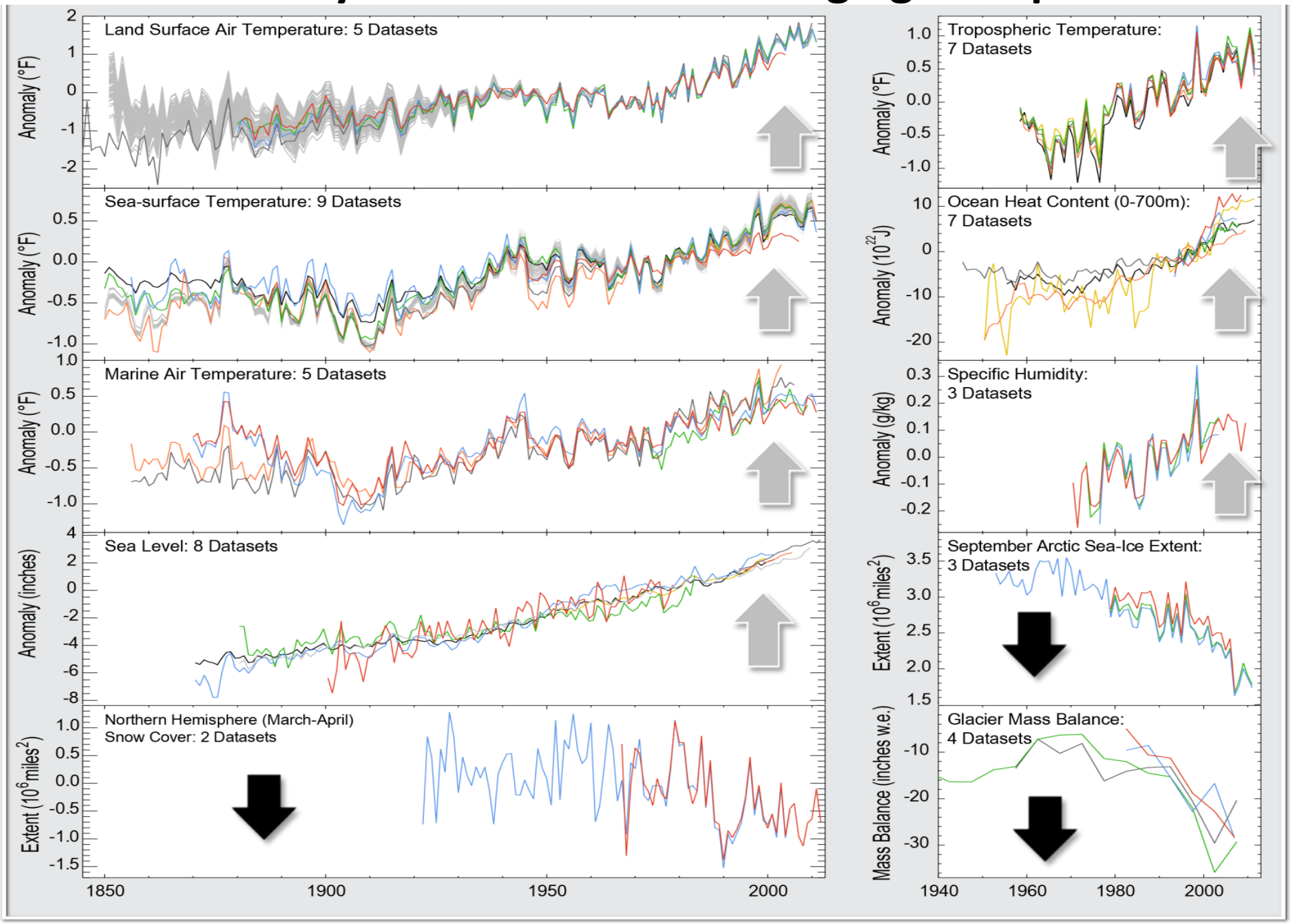
This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution. (Source: NOAA)

Global Climate is Changing

Ten Indicators of a Warming World



The ten key indicators are all changing as expected

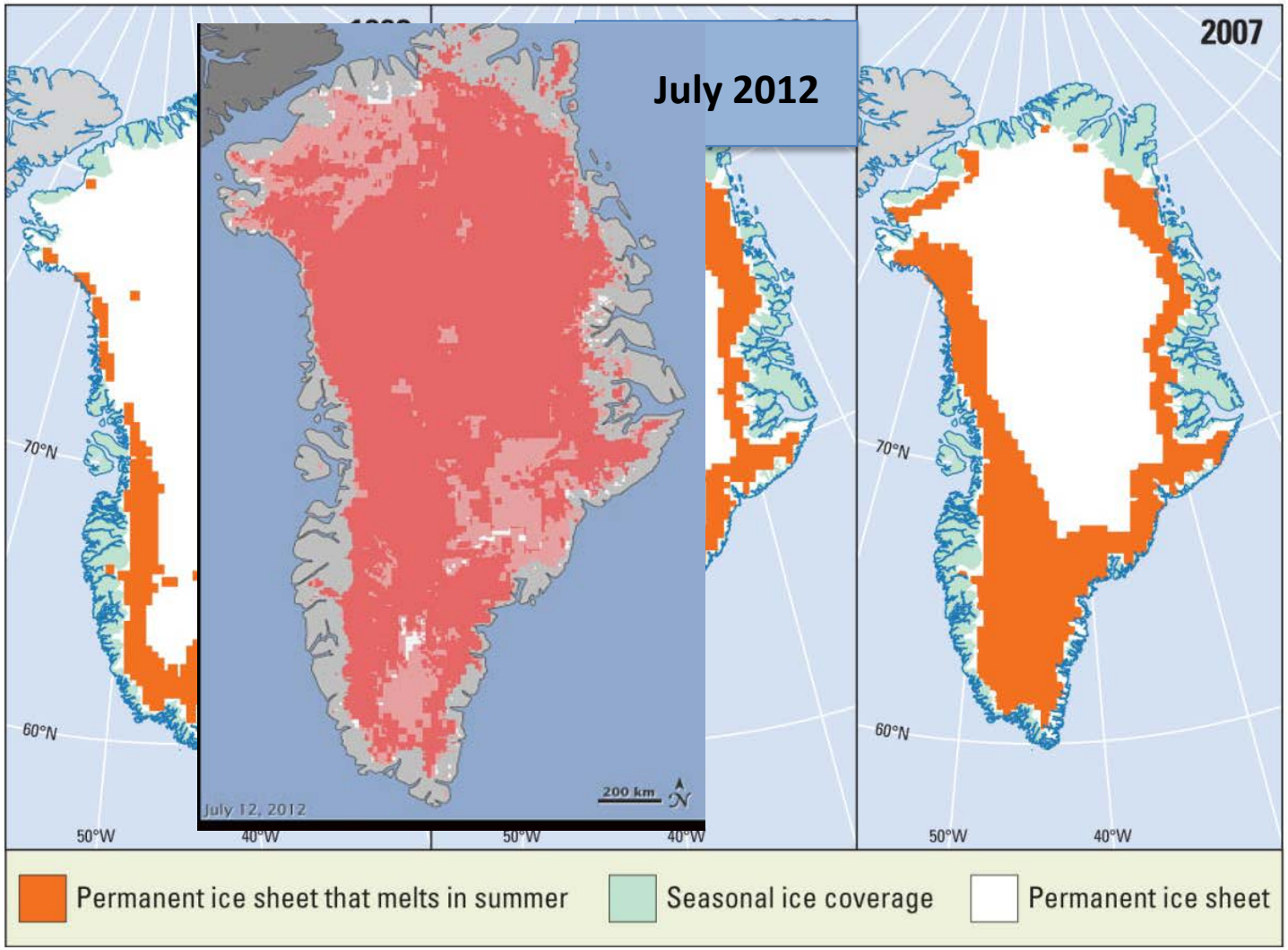


Glaciers are melting all around the globe

contributing to sealevel rise

- snow and ice are melting rapidly.
- In Glacier National Park, there were 150 glaciers in 1850. Today, there are 26.

The Greenland ice sheet is melting

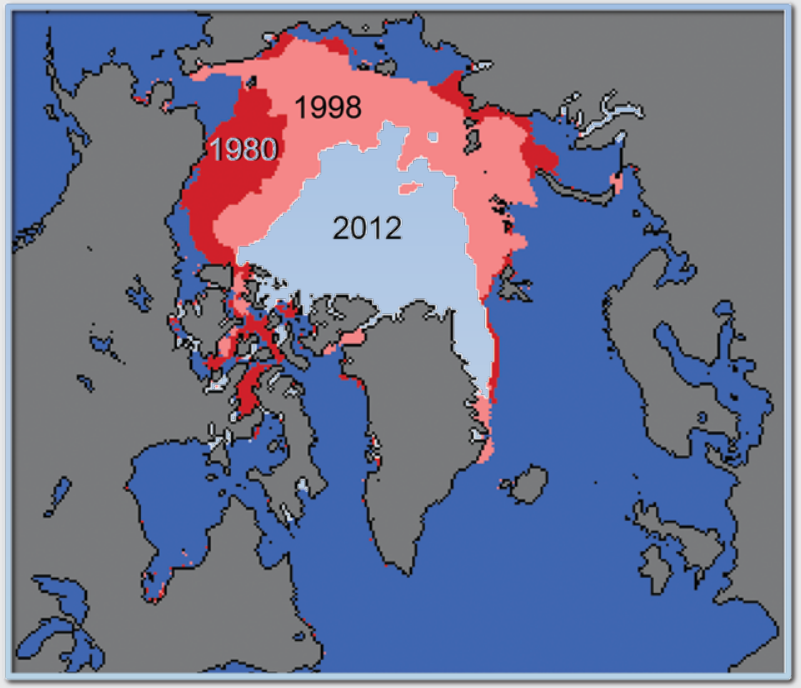


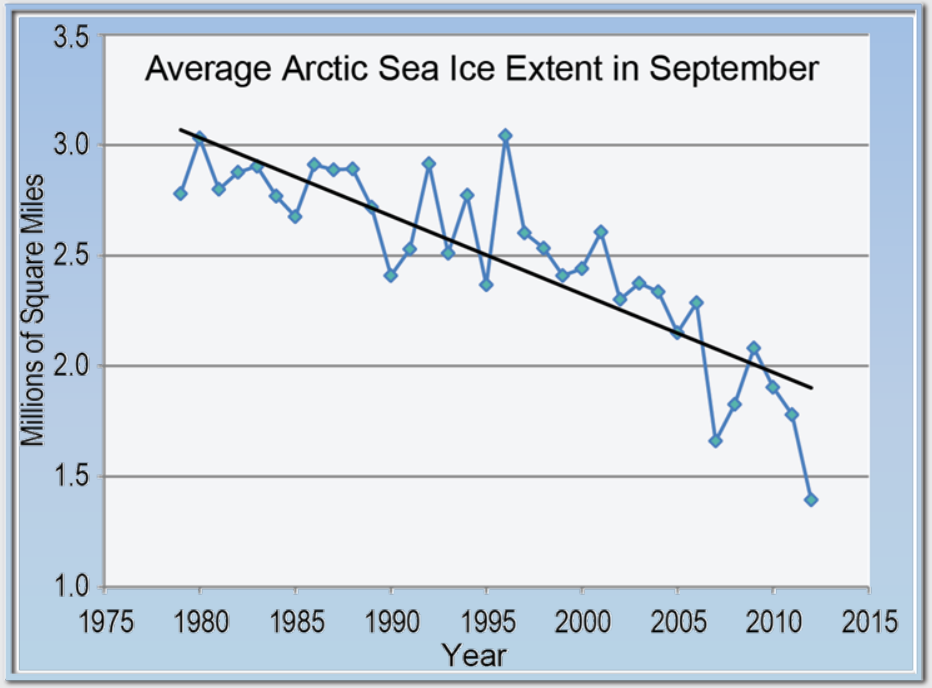
WDR: 2010, & National Snow and Ice Data Center

Contains about 7 meters of sealevel rise

Change is also Apparent Across the Arctic

Arctic Sea Ice Decline





In 1980, arctic ice covered all the red, pink and white regions

Sea ice extent in 2012 was 40% less

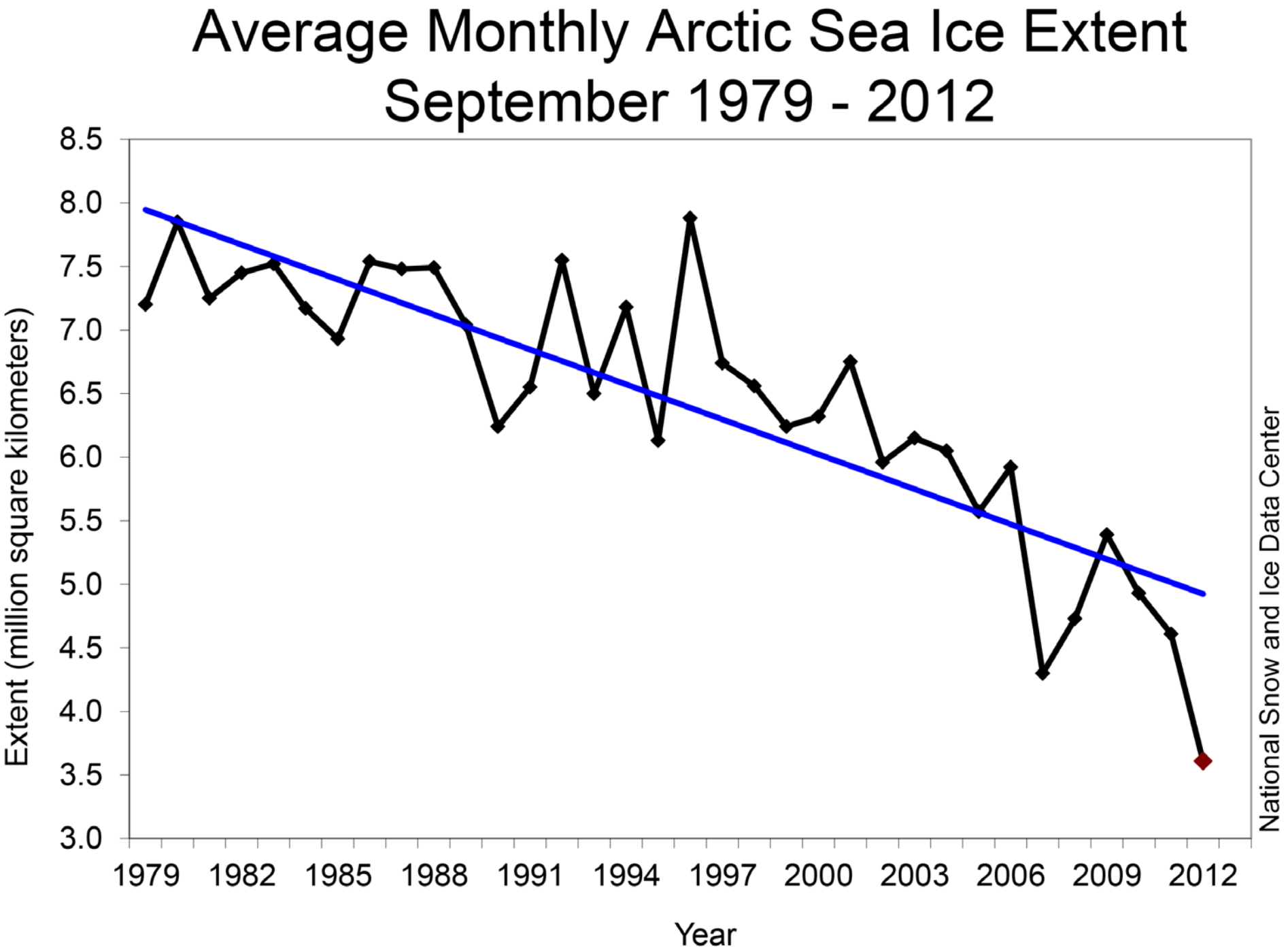
U.S. Global Change Research Program
National Climate Assessment

U.K. *Daily Mail*, September 15, 2013

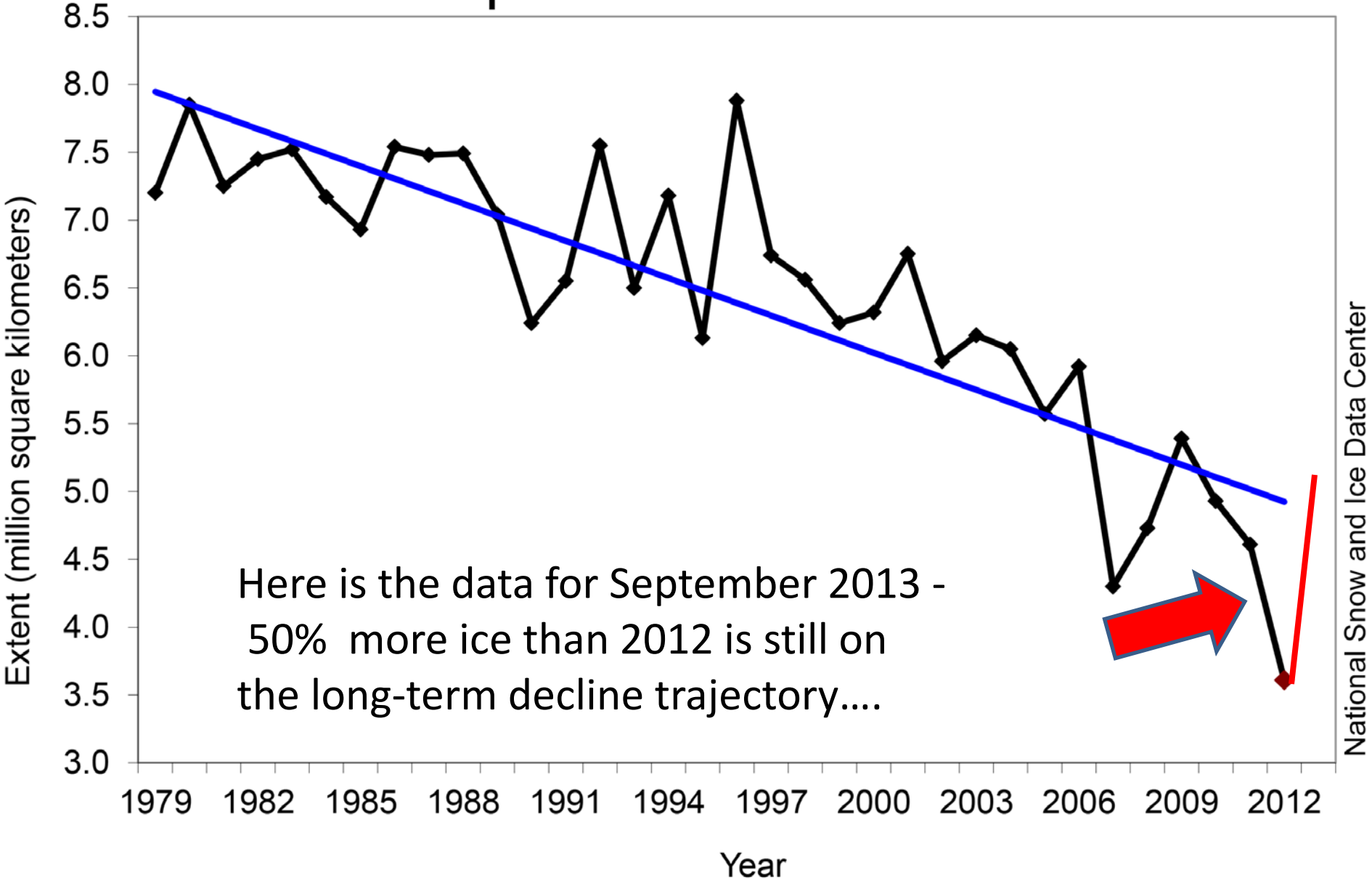
And now it's global COOLING! Record return of Arctic ice cap as it grows by 60% in a year

CONTRACTION: This Nasa satellite image shows the ice at the smallest extent on record, with much of the Arctic Ocean uncovered

RECOVERY: Contrary to predictions that the ice would have vanished by this summer, it has actually increased by 60 per cent from last year


Average Monthly Arctic Sea Ice Extent
September 1979 - 2012
Extent (million square kilometers)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
Year
National Snow and Ice Data Center

Average Monthly Arctic Sea Ice Extent
September 1979 - 2012



II. Impacts are already being felt

Independent evidence for a warming world

EARLIER SPRING
Lilacs, honeysuckle, and other harbingers of spring are flowering 1-2 weeks earlier in the year.

Independent evidence for a warming world

SHIFTING CROPS AND PLANTS

Center of blueberry production has shifted northward, from Maine to Quebec.

Independent evidence for a warming world

EXTREME HEAT
Record high temperatures and heat waves 2x more frequent.

Independent evidence for a warming world

DROUGHT
Crop losses of $5B per year since 1980s.

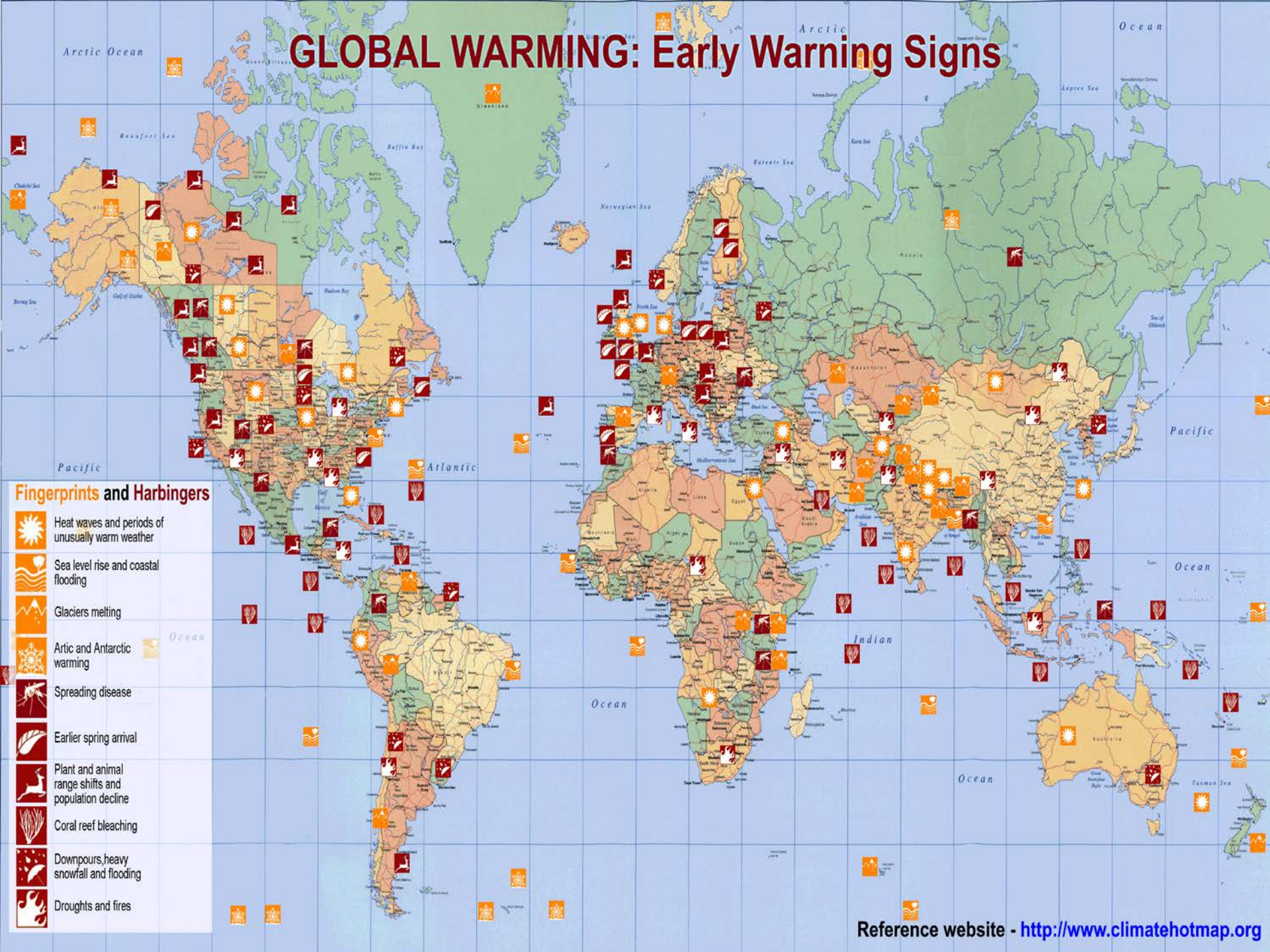
Independent evidence for a warming world

PESTS MOVING NORTH
Less cold days to keep red ants & kudzu at bay

Independent evidence for a warming world

Responses to warming temperatures seen in more than 25,000 physical and biological systems around the world.

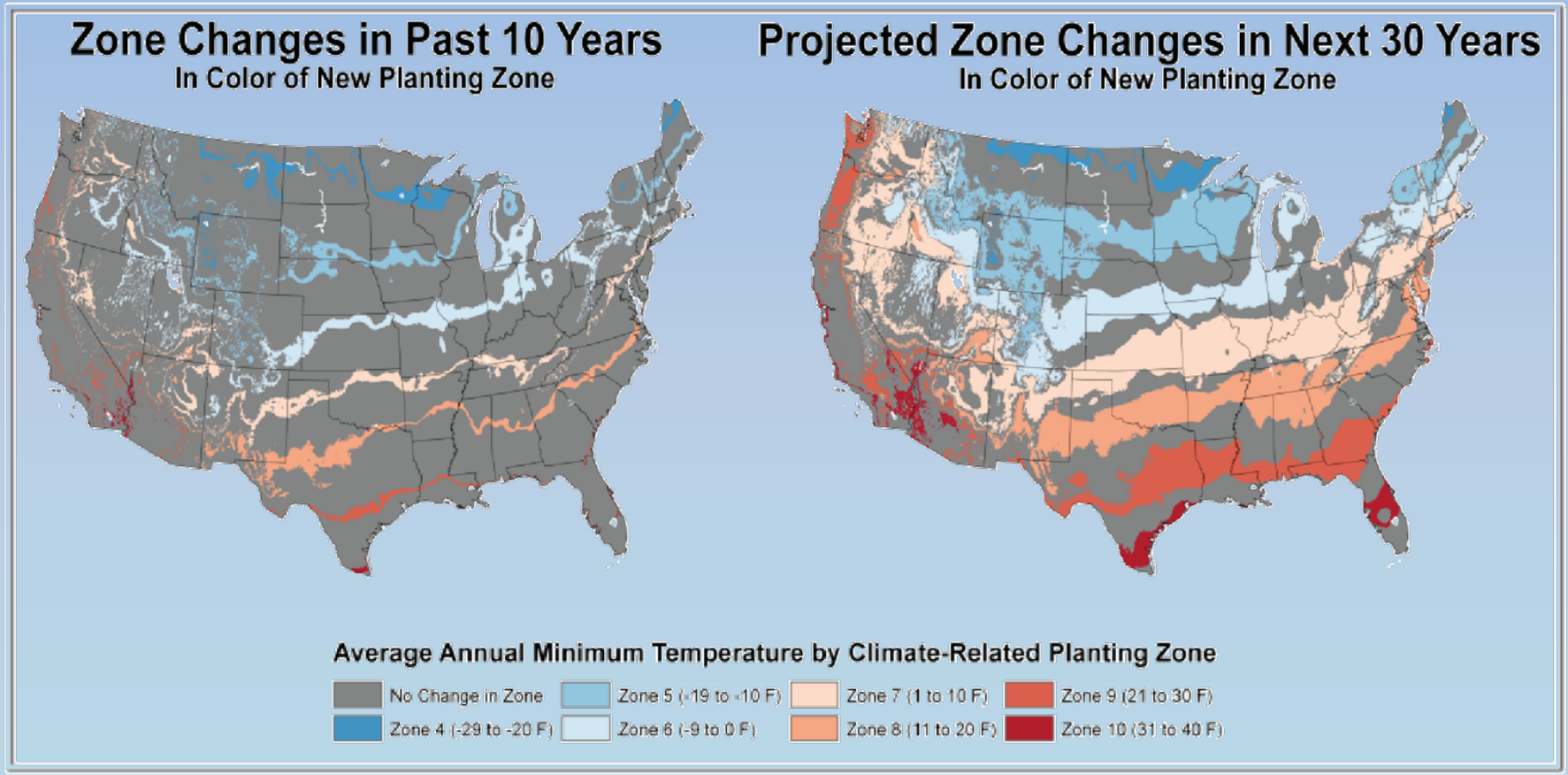
GLOBAL WARMING: Early Warning Signs



Reference website - http://www.climatehotmap.org

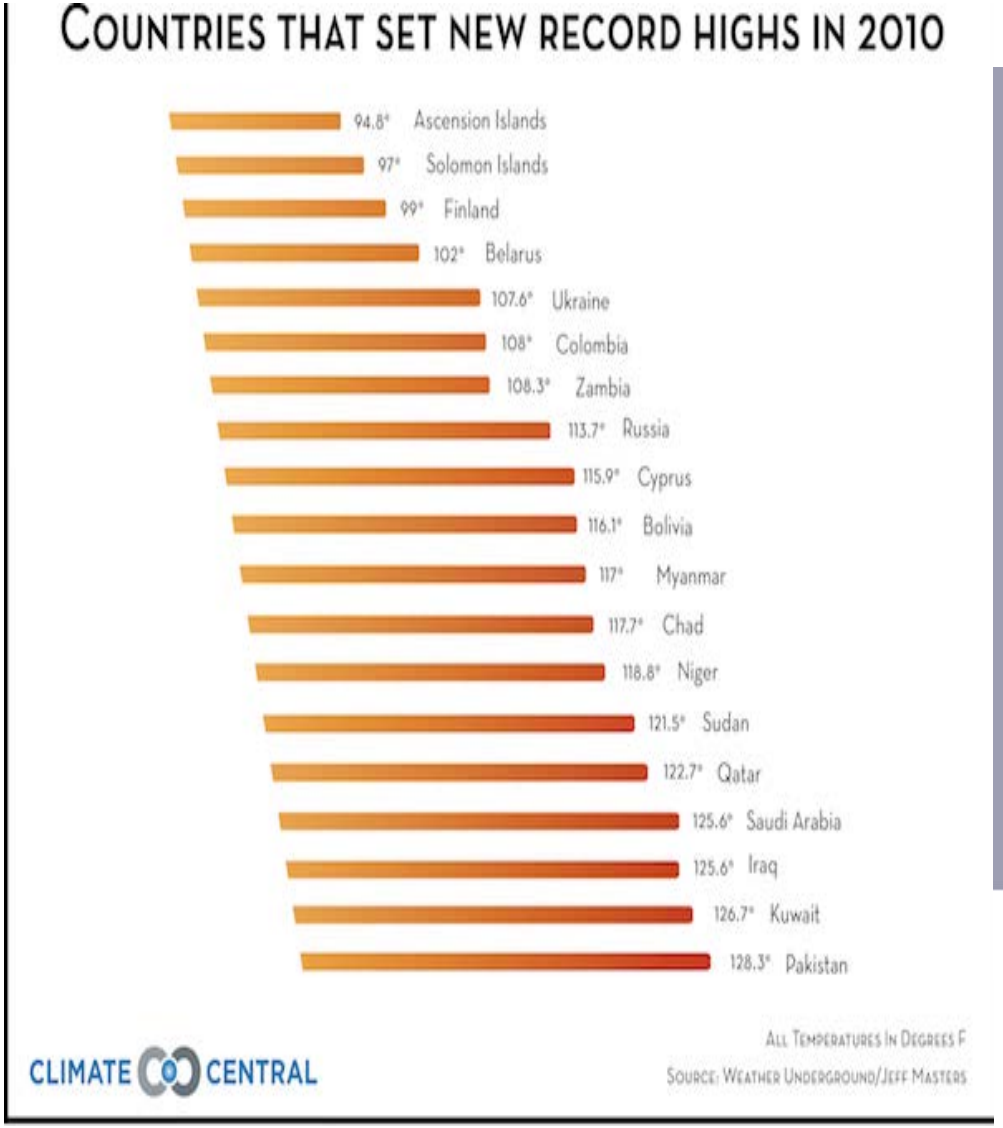
Impacts to crops

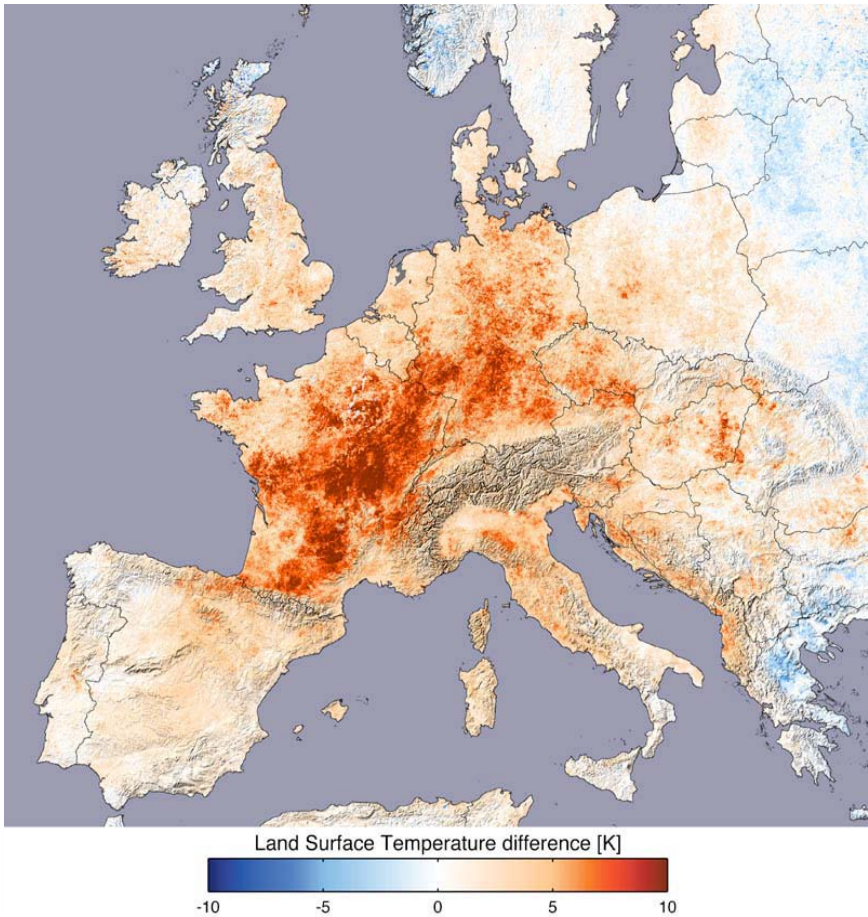
Shift in Plant Hardiness Zones



U.S. Global Change Research Program
National Climate Assessment

Record heat events recorded in many countries





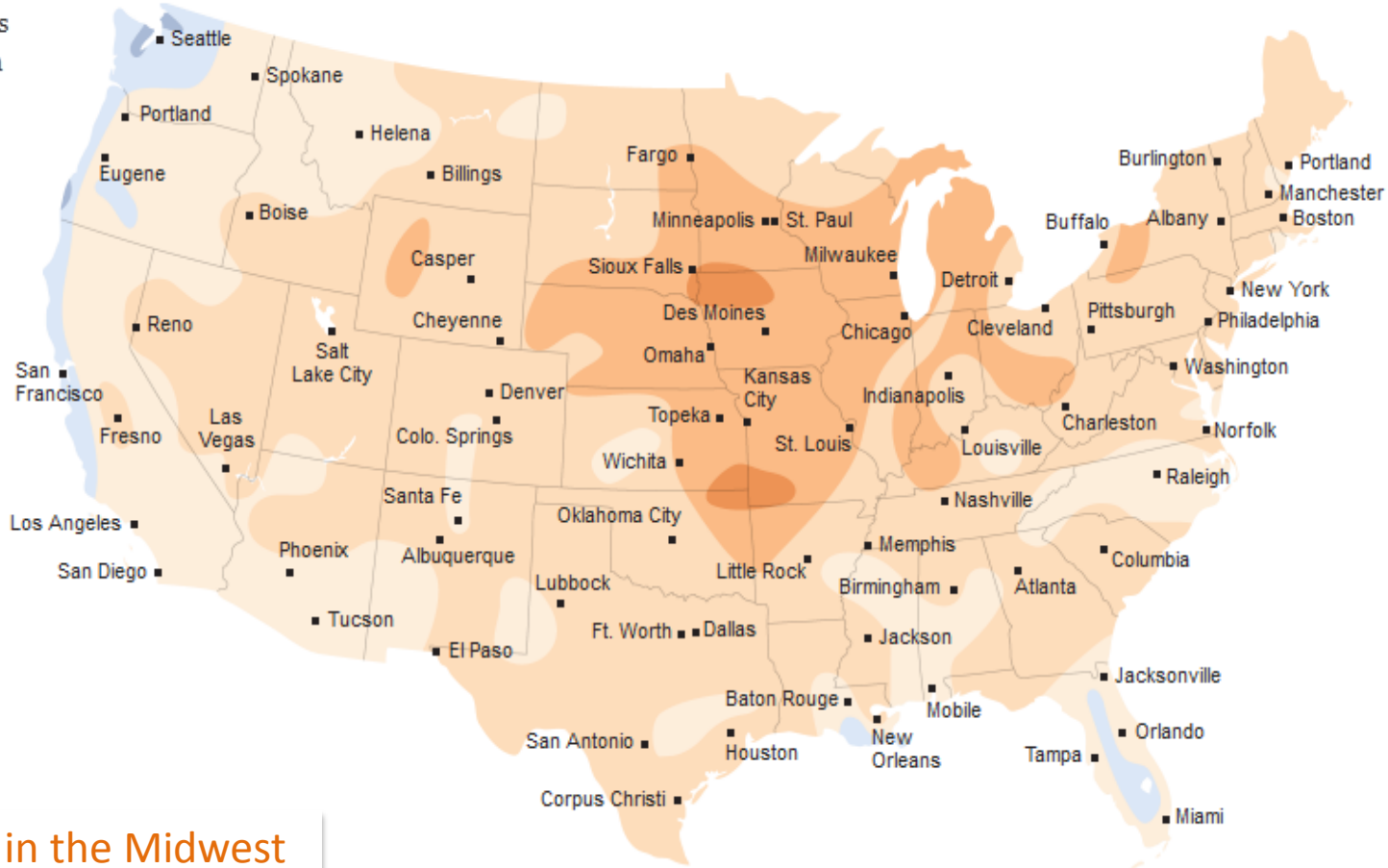
NASA MODIS satellite, Hegerl et al (2007)

The record high temperatures in western Europe in the summer of 2003 were associated with a spike of about 70 000 more deaths than the equivalent periods in previous years.

The Midwest had some of the largest temperature anomalies in 2012

Record-Setting Heat Across the U.S. in 2012

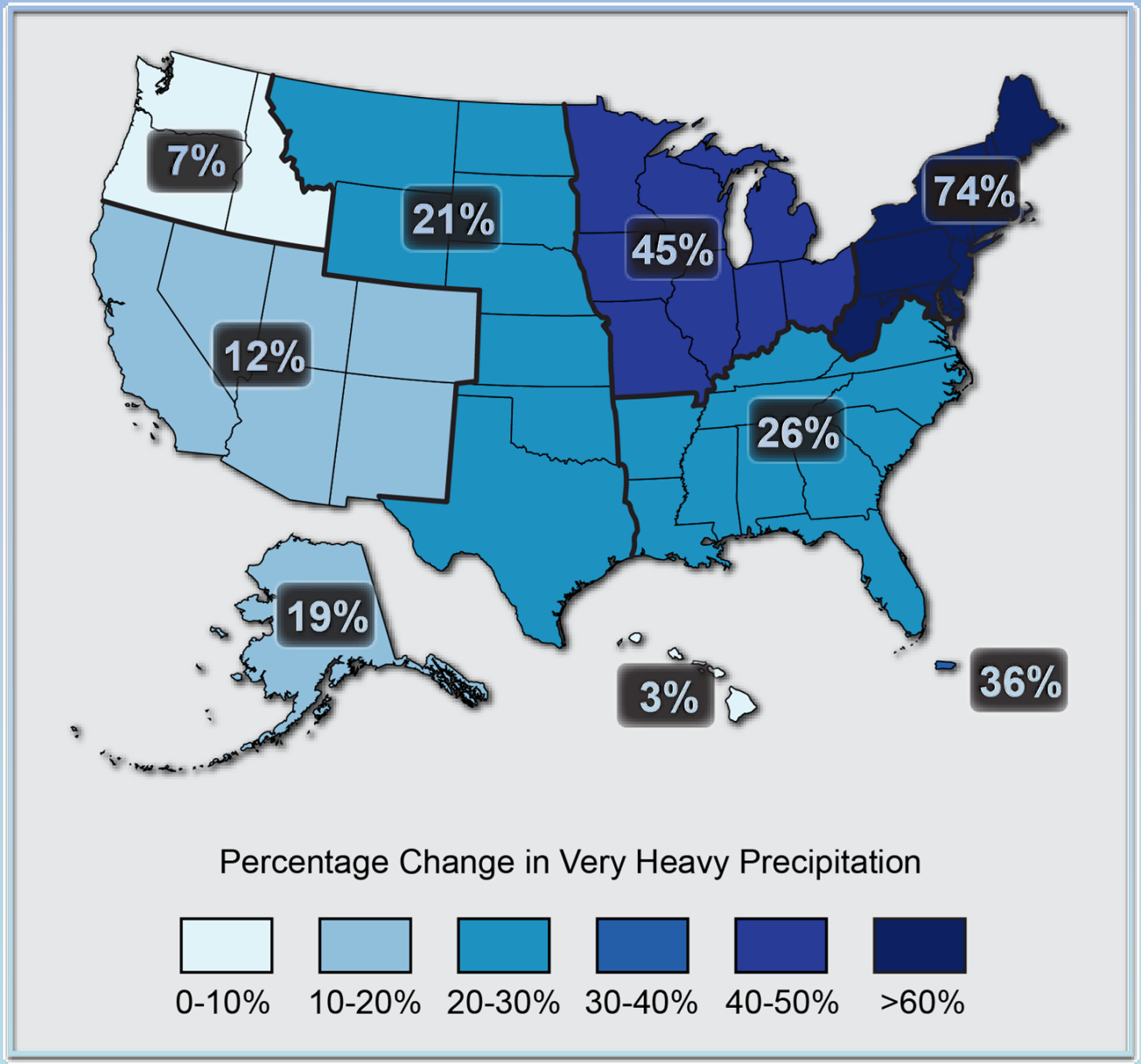
The average temperature across the contiguous United States in 2012 was 55.3° (3.2° above normal). This ranks as the warmest year since records began in 1895. Related Article »



Biggest changes in the Midwest

NYT, 1/13/13 - from NOAA, Accuweather

Increased Volume of Rainfall in Heavy Precipitation Events



Change based on 1901 – 1960 average, top 1% of all daily events

U.S. Global Change Research Program
National Climate Assessment

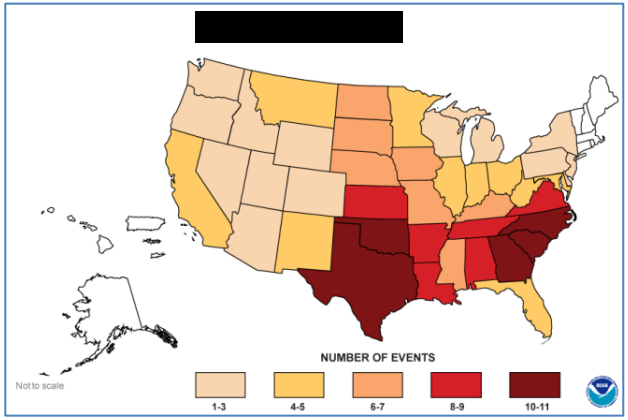
U.S. Global Change Research Program
National Climate Assessment

The increasing intensity of storms and shifting of rainfall patterns toward more spring precipitation in the Midwest may lead to more scenes similar to this one.

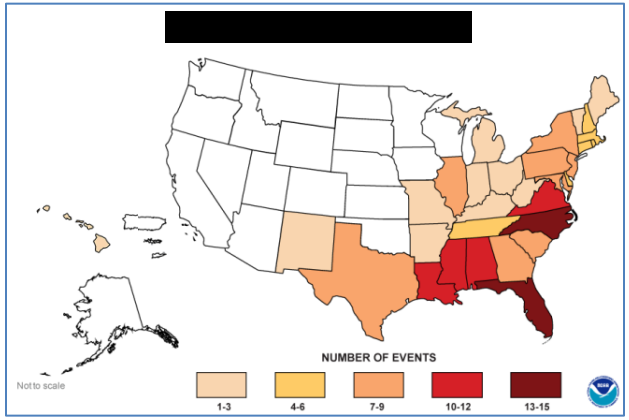
Extreme Events are Increasing

U.S. Billion-Dollar Weather and Climate Disasters: 1980 – 2011

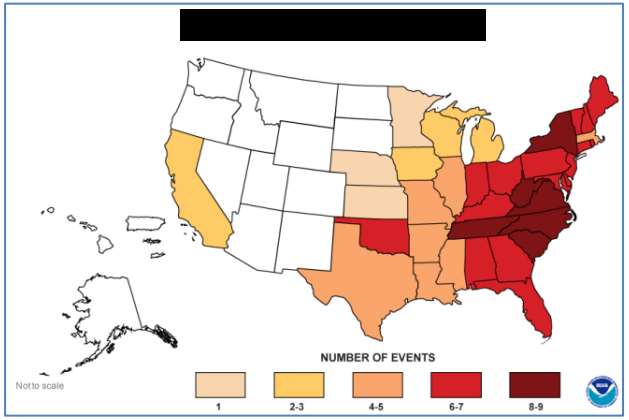
Drought and Heatwaves



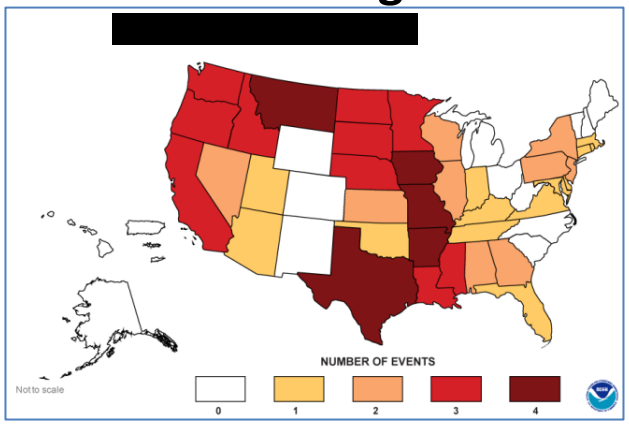
Hurricanes and Tropical Storms



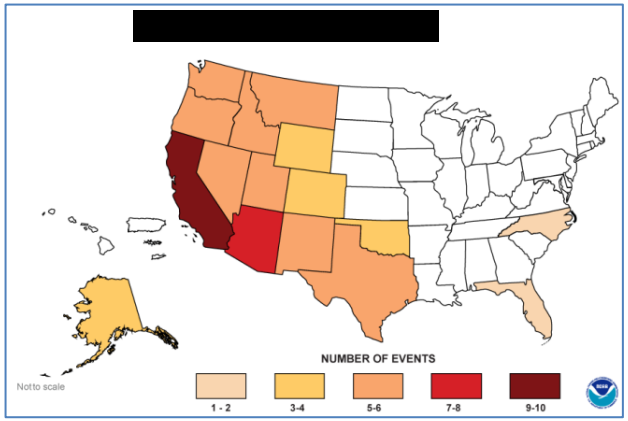
Winter Storms and Crop Freezes



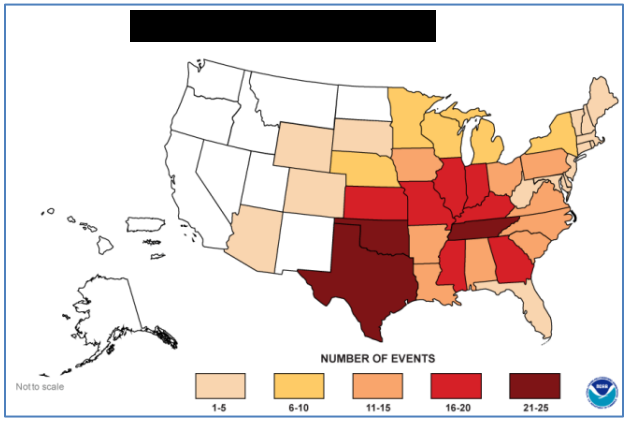
Flooding



Wildfires

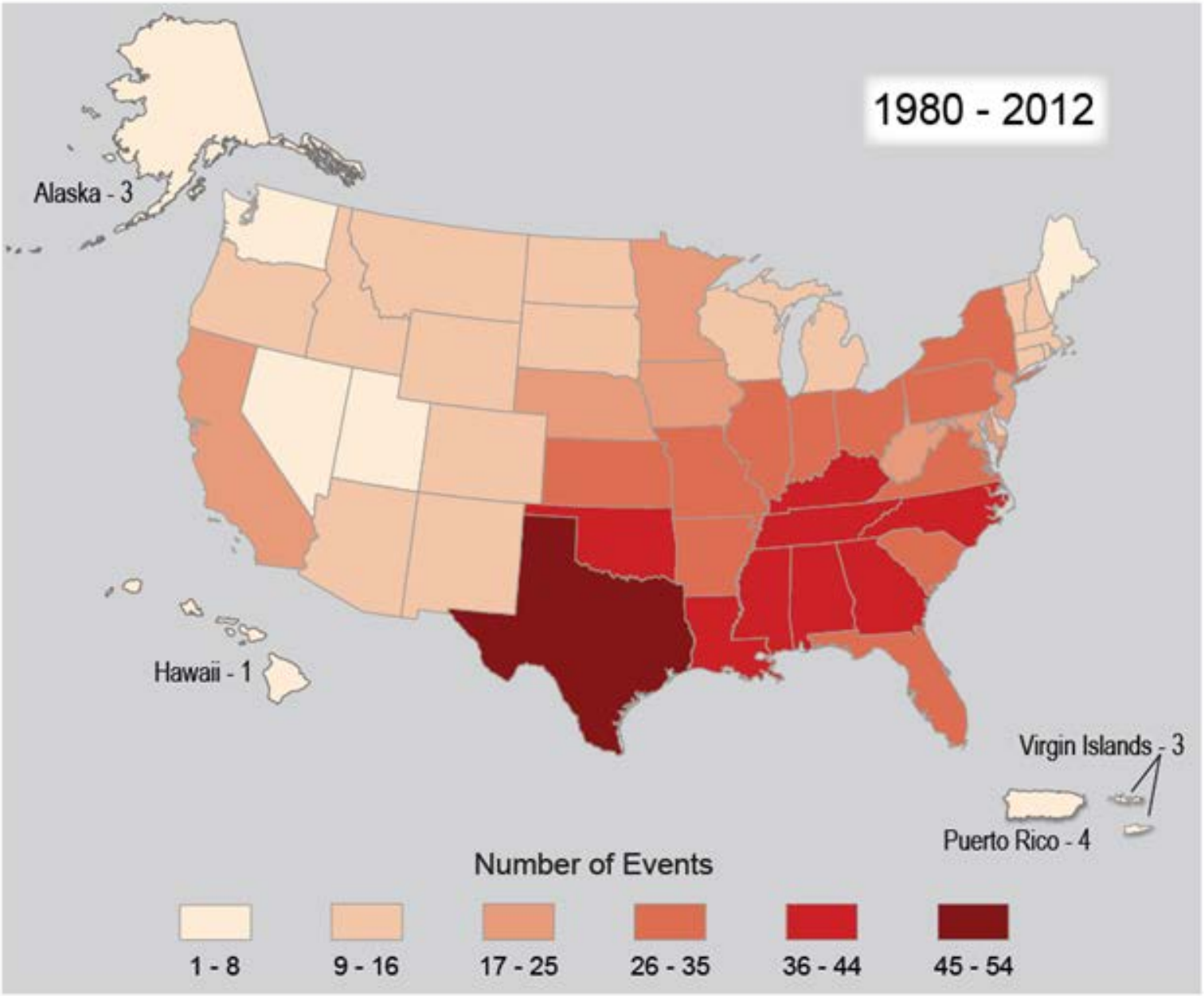


Severe Local Storms



National Climate Data Center, NOAA, 2012

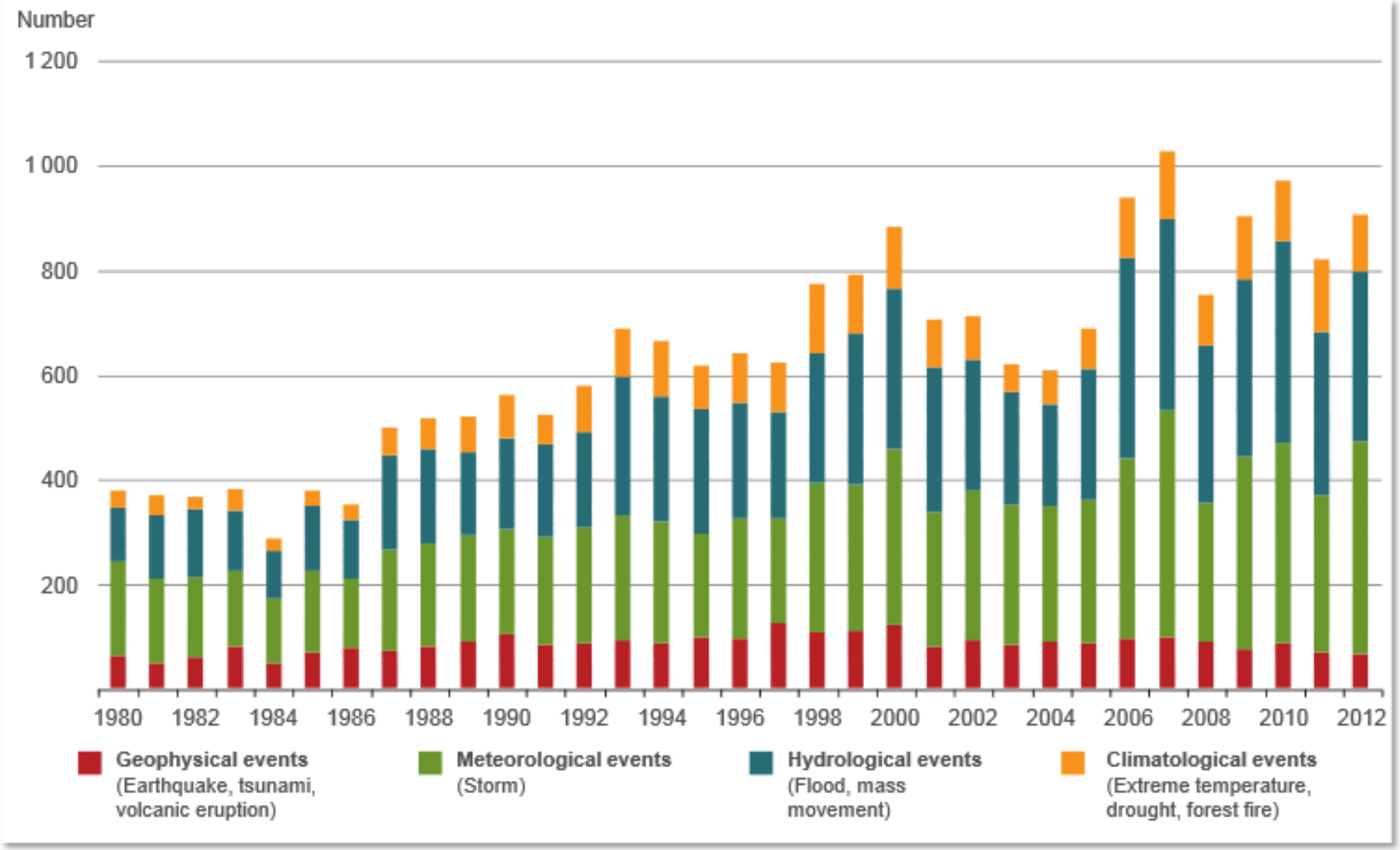
Billion Dollar Weather/Climate Disasters



NatCatSERVICE

Natural catastrophes worldwide 1980 – 2012

Number of events



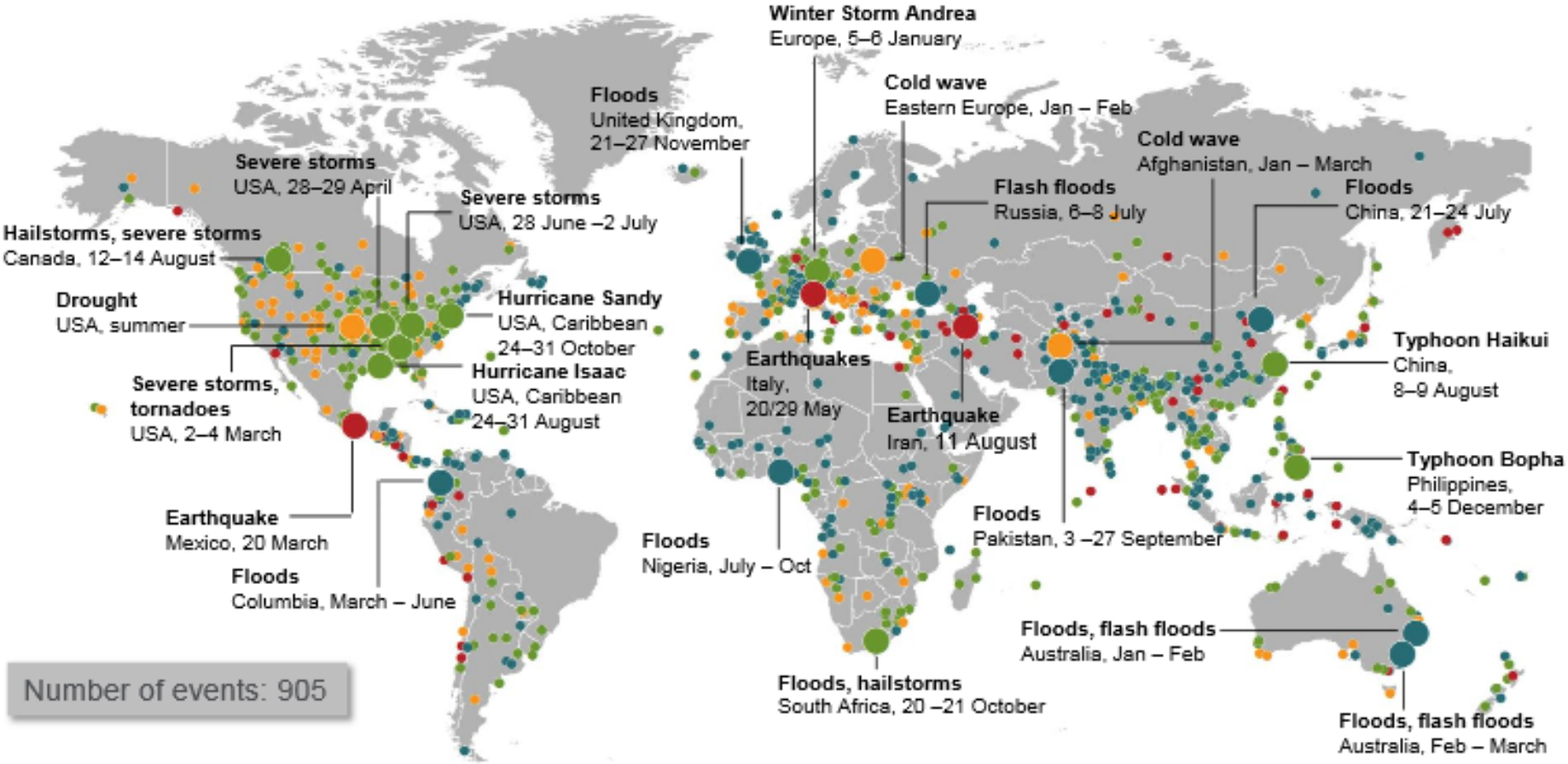
© 2013 Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE – As at January 2013

NatCatSERVICE

Natural Catastrophes 2012

World map

Munich RE



- Natural catastrophes
- Selection of significant Natural catastrophes
- Geophysical events (earthquake, tsunami, volcanic activity)
- Meteorological events (storm)
- Hydrological events (flood, mass movement)
- Climatological events (extreme temperature, drought, wildfire)

© 2013 Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE – As at January 2013

Natural catastrophes worldwide 2012

The five costliest natural catastrophes for the insurance industry

Munich RE

Date	Region	Event	Fatalities	Insured losses US$ m
24-31.10.2012	USA, Caribbean	Hurricane Sandy	220	25,000
June-Sept. 2012	USA	Drought		15,000-17,000 agriculture losses / average year approx. US$ 9bn
2-4.3.2012	USA	Severe storms, tornadoes	41	2,500
28-29.4.2012	USA	Severe storms, tornadoes	350	2,500
28.6-2.7.2012	USA	Severe storms, tornadoes	18	2,000

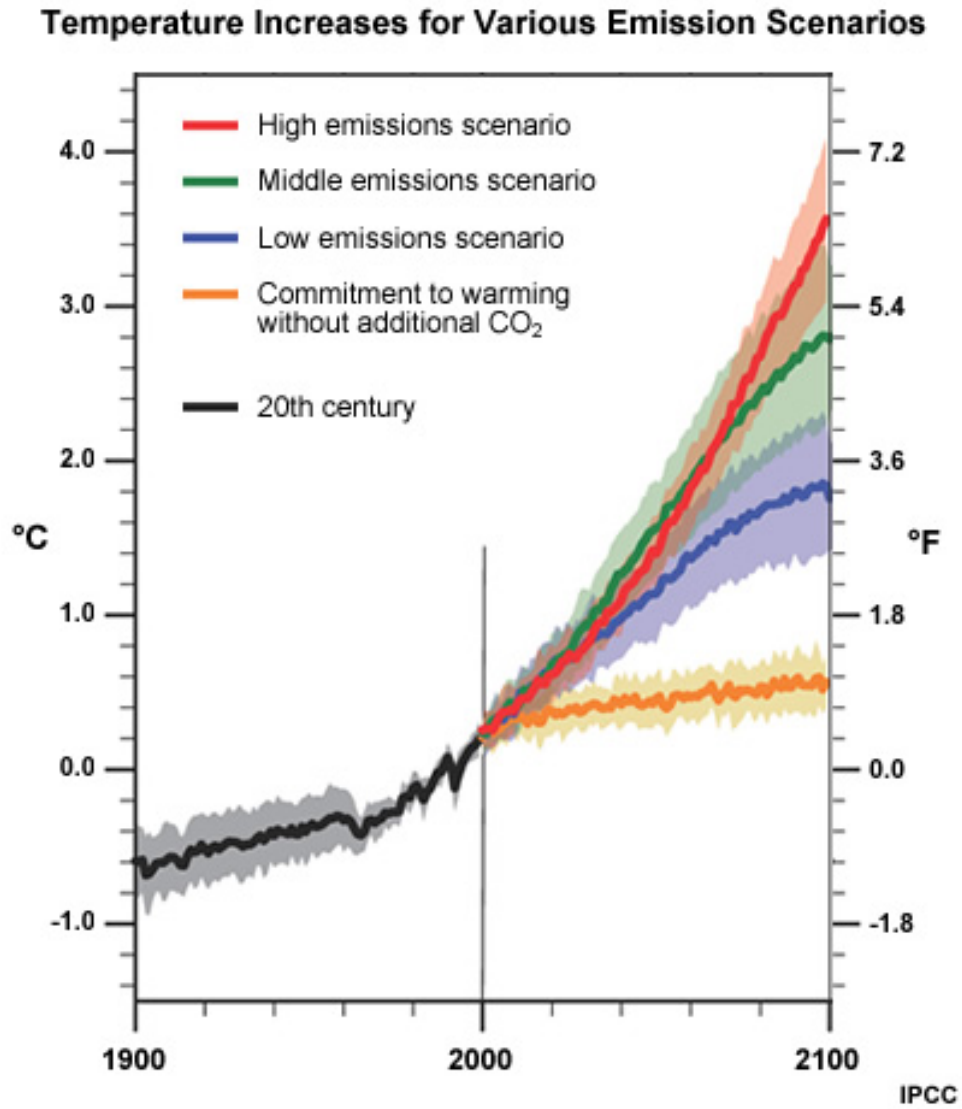
Source: Geo Risks Research, NatCatSERVICE – As at January 2013

© 2013 Munich Re

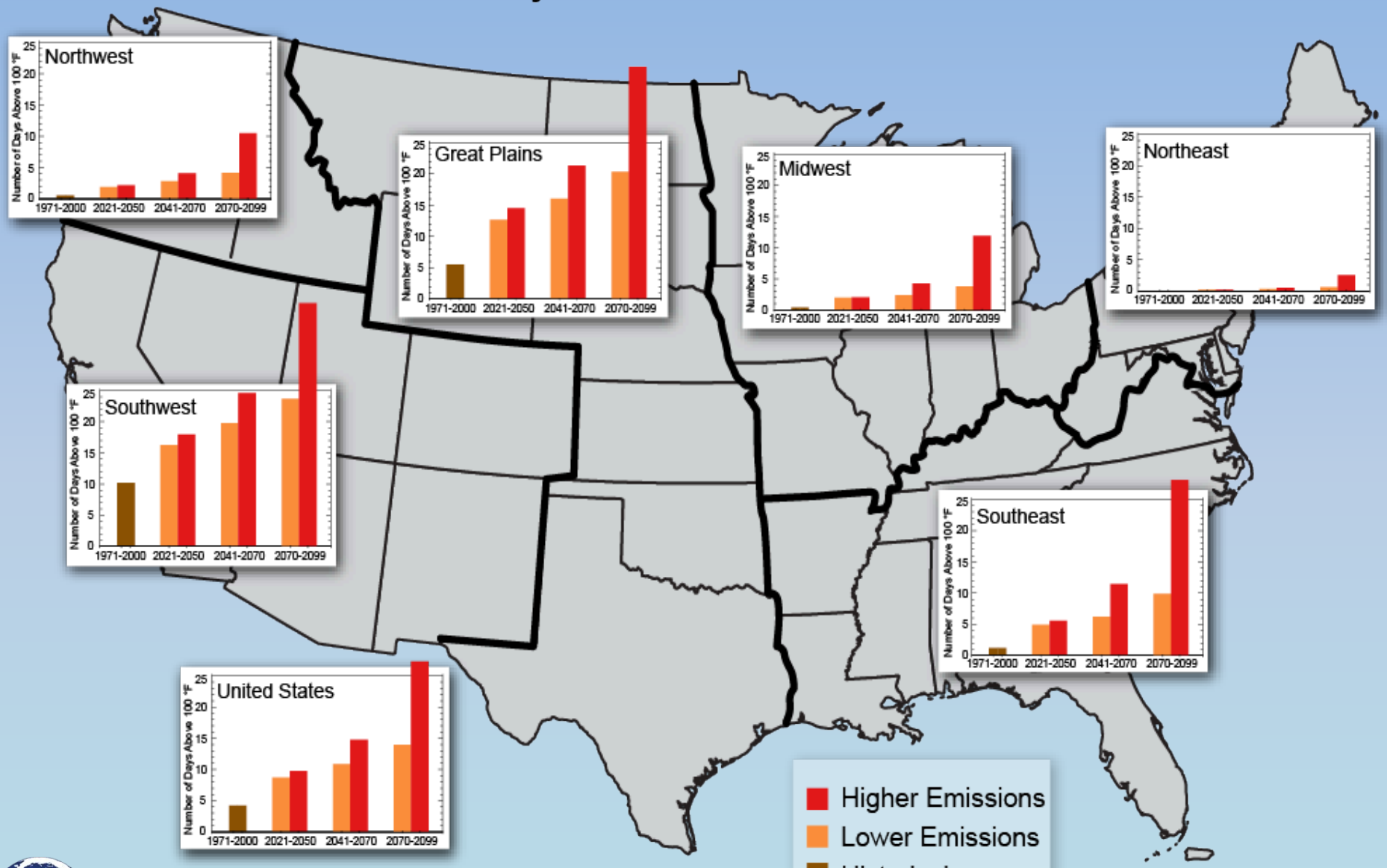
III. What does the future portend?

Climate Model Projections

We are headed well past a 2º C world under 'business as usual scenarios



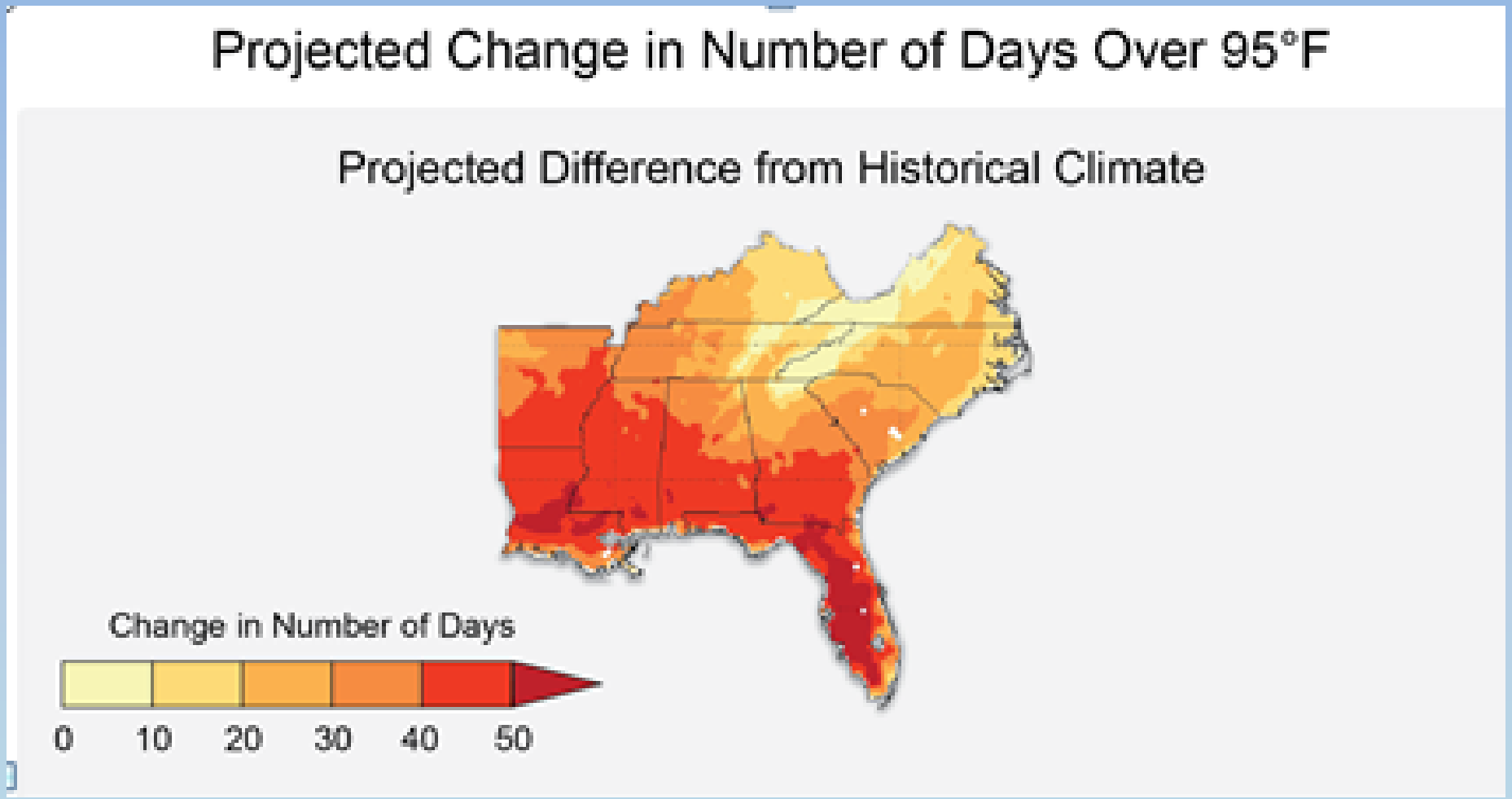
Days Over 100°F



U.S. Global Change Research Program

National Climate Assessment

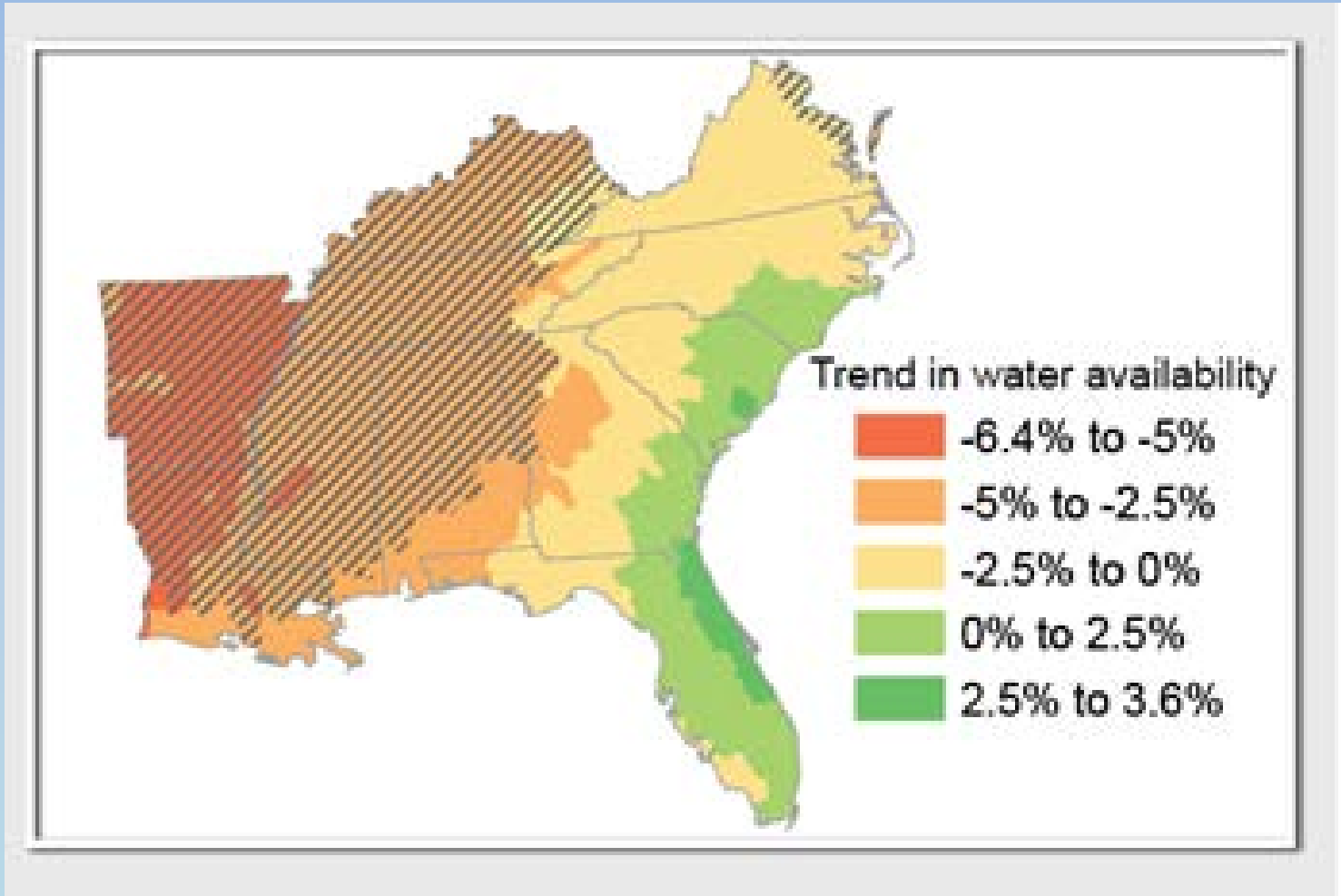
By 2040- 2070



http://scenarios.globalchange.gov/report/regional-climate-trends-and-scenarios-us-national-climate-assessment-part-2-climate-southeast

U.S. Global Change Research Program
National Climate Assessment

Future dcadal trend in water availability



U.S. Global Change Research Program
National Climate Assessment

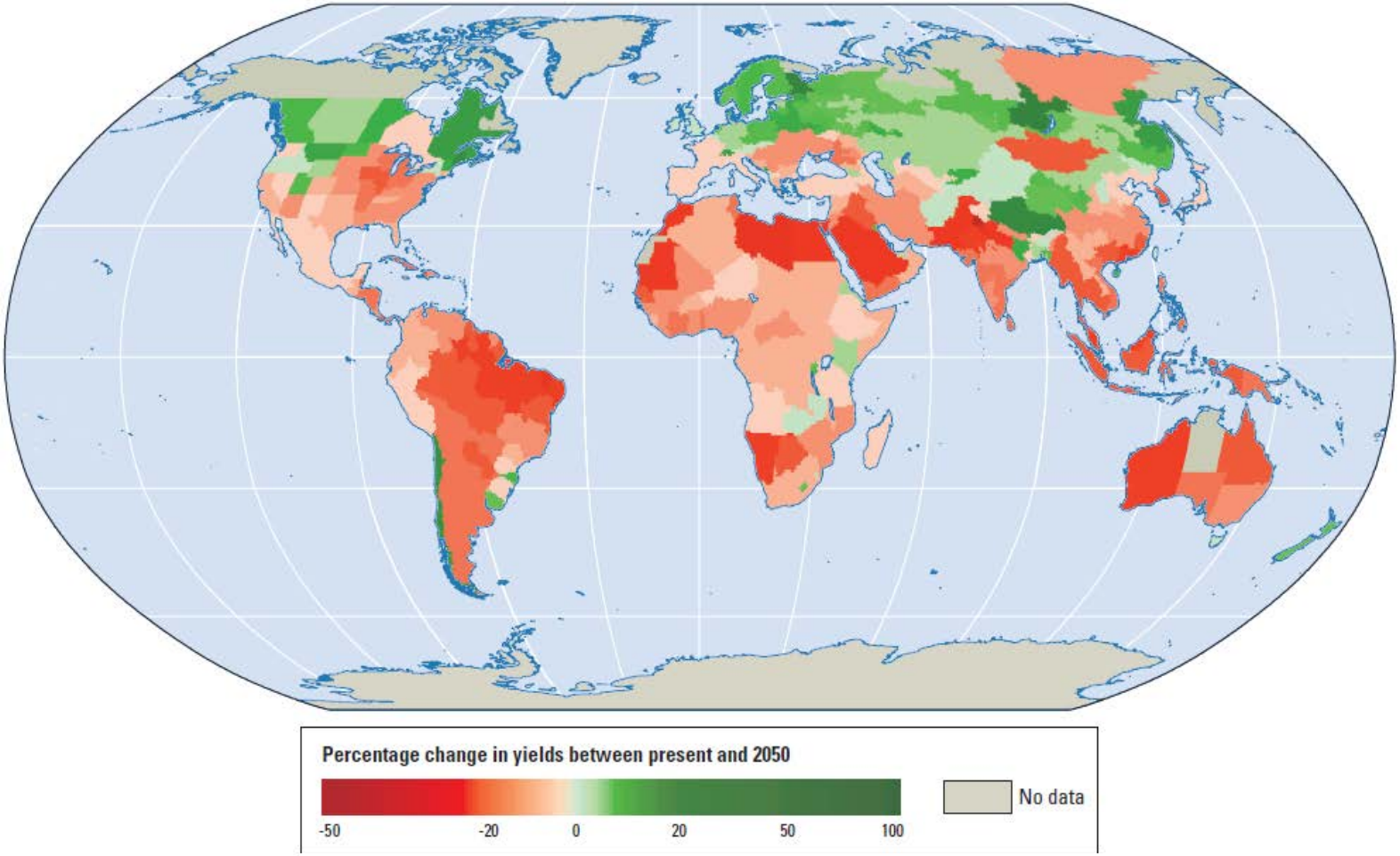
The hatched areas are those where the predicted negative trend in water availability is statistically significant (with 95% confidence).

Southeast Impacts

- Primary impacts: **extreme heat events, decreased water availability & sealevel rise**
- **Southeast is expected to have the highest increase in heat index (a measure of comfort that combines temperature and relative humidity) of any region of the country**
- Daily rainfall intensities have increased
- Up to 10°F increase by 2100 for interior States of the region
- Livestock yield may decline with a 9ºF increase
- Summer heat stress is projected to reduce crop productivity, especially when coupled with increased drought
- Decreased water availability, exacerbated by population growth and land-use change, will increase competition for water & impact the region's economy & unique ecosystems.

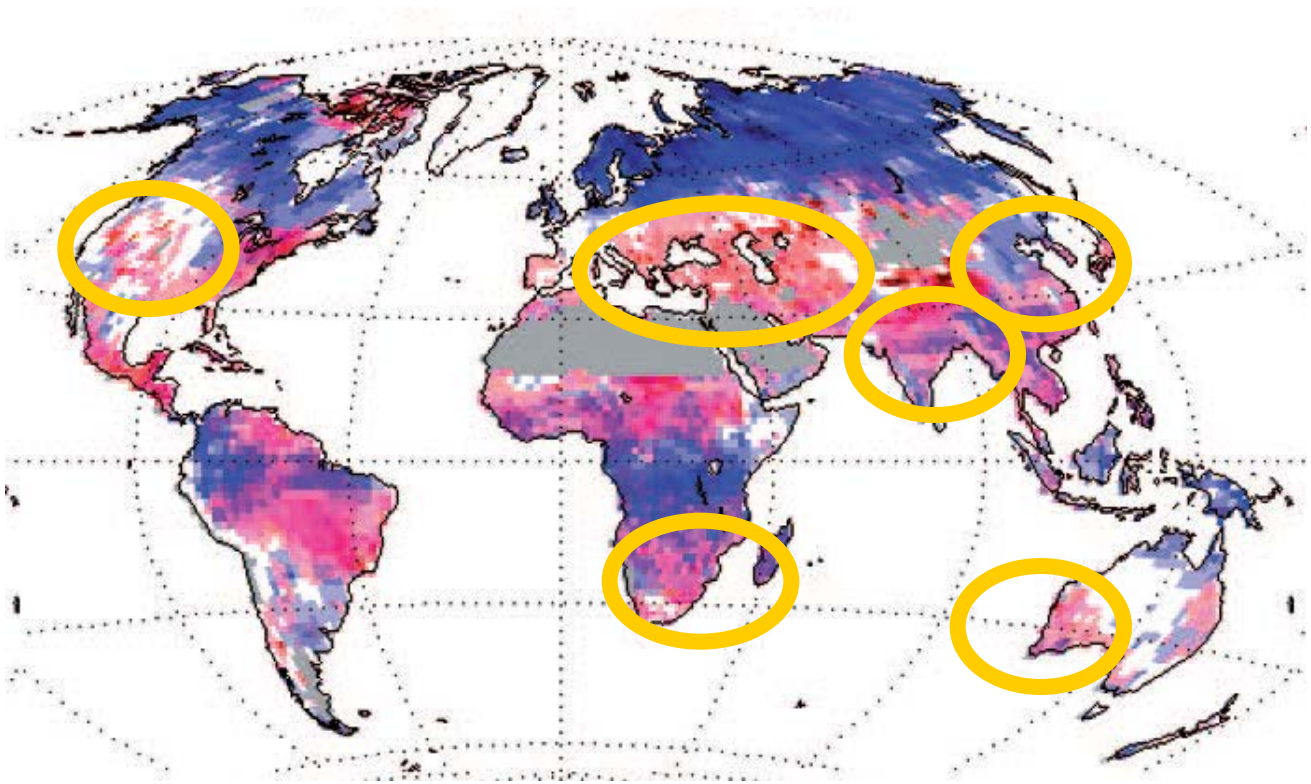
U.S. Global Change Research Program
National Climate Assessment

Development consensus: The poor will suffer most



World Development Report, 2010

Availability of irrigation water will decrease in key areas

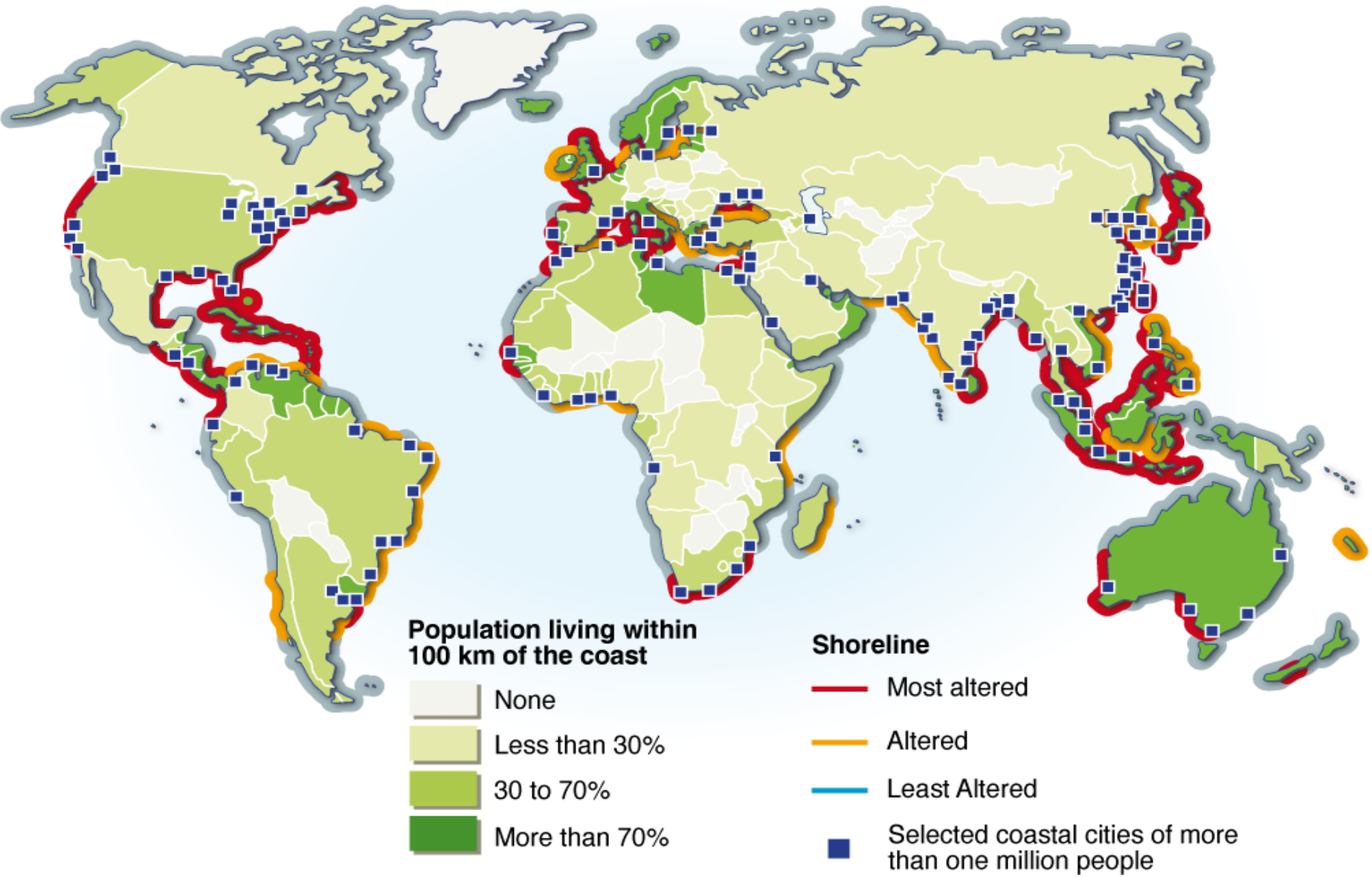


Scholze et al. (2006)

Blue tendency to increase

Red tendency to decrease

More environmental refugees

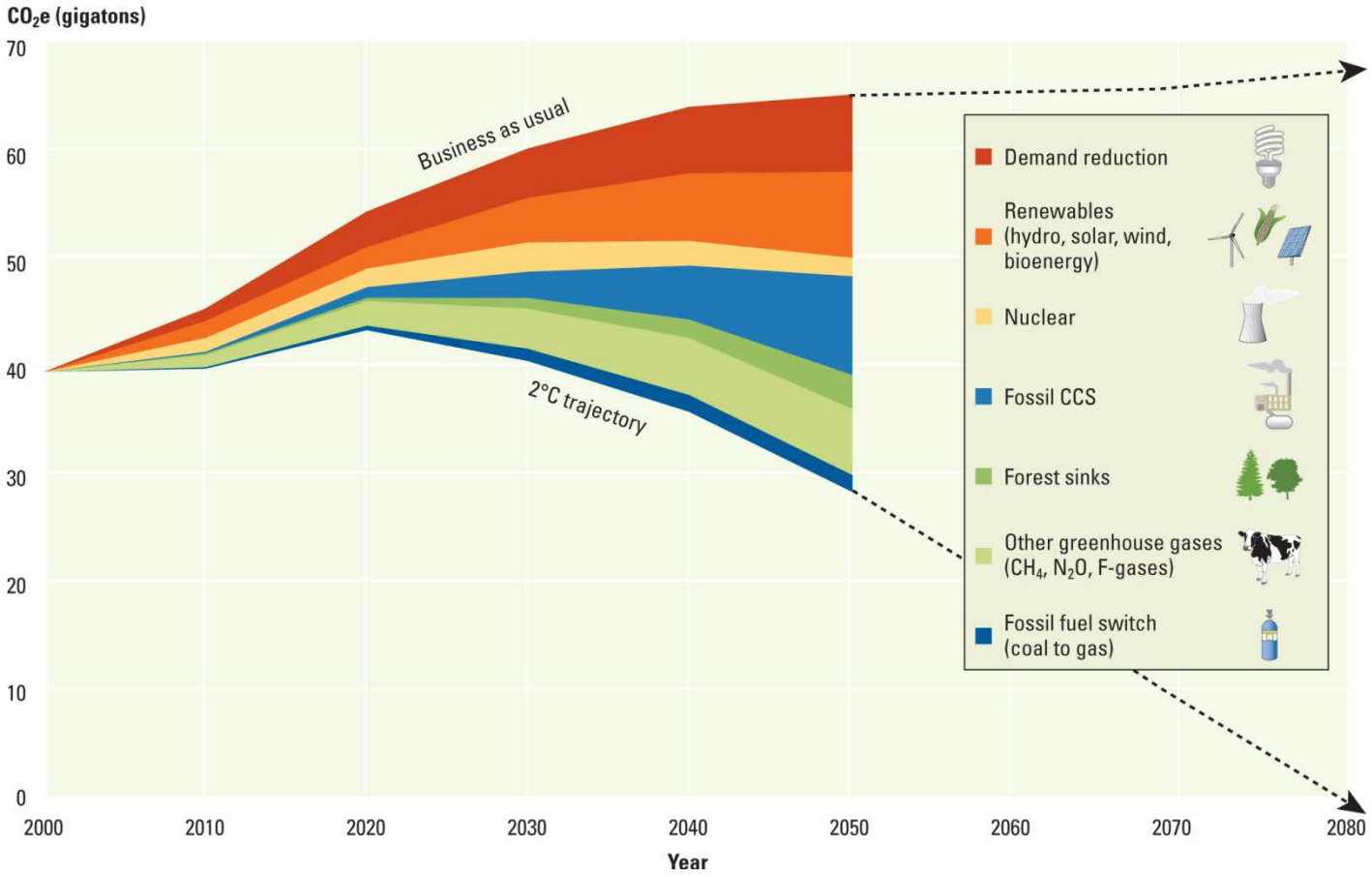


UNEP, Global Environmental Outlook-4 ,2007

IV. Ways forward

Act differently:

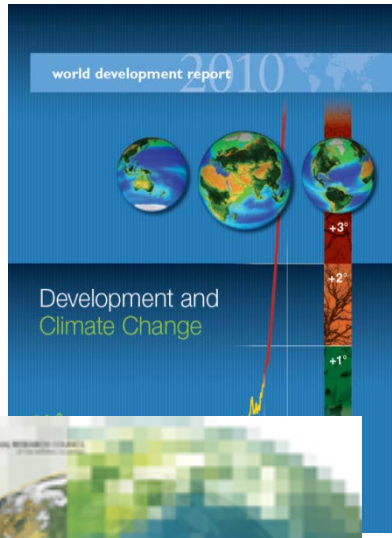
Radically transform energy systems

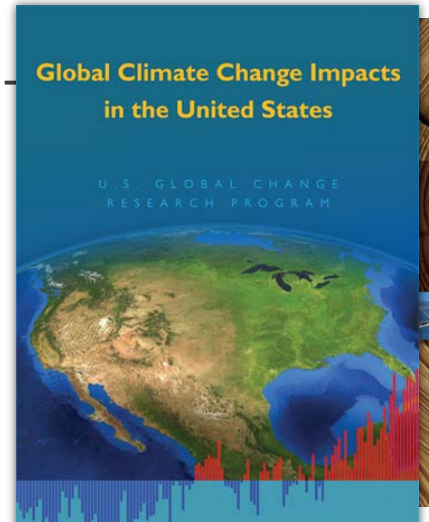


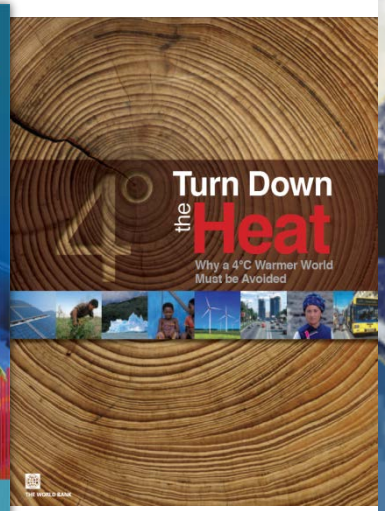
World Development Report 2010

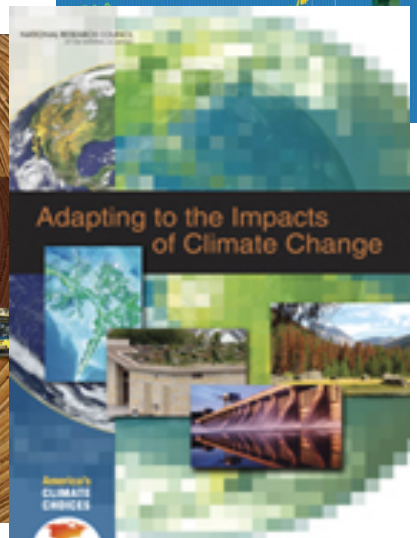
We must Adapt to climate change, adaptively: how can we help make *robust* rather than optimal decisions

- Infrastructure to withstand new “extremes”
- Seed varieties that perform well in droughts/floods/heat; seed banks
- Prioritize lands to preserve and manage multiple threats
- Emergency response plans, early-warning alert systems
- Develop social safety nets / insurance
- Information systems / share best practices
- Regional assessments - done iteratively





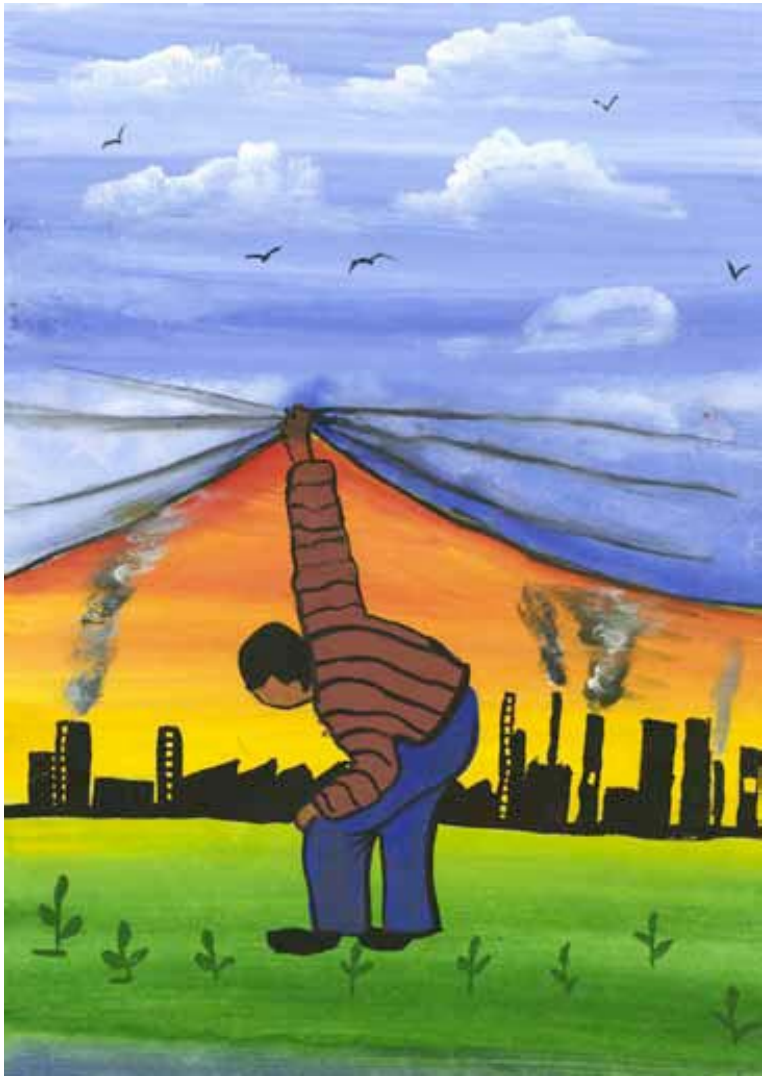




We are responsible for our own future –
more so than any prior generation
Bangladesh • © Gary Braasch/World View of Global Warming.org

PAINT FOR THE PLANET

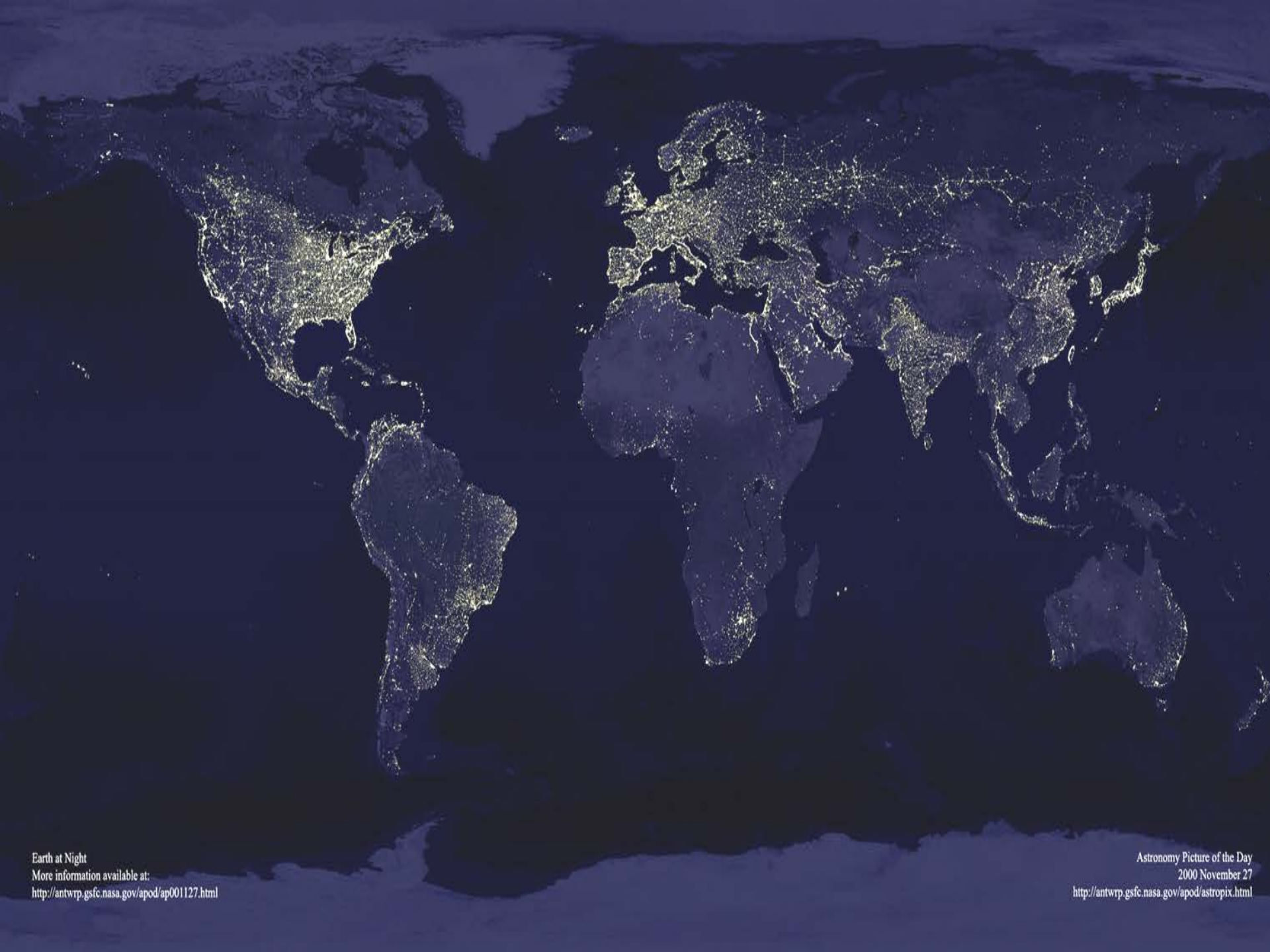
UNite to combat CLIMATE CHANGE UNEP



“It is our collective responsibility to find ‘unselfish’ solutions and fast before it’s too late to reverse the damage caused every day.”

Maria Kassabian, age 10, Nigeria

Drawings from children around the world…..


Earth at Night
More information available at:
http://antwrp.gsfc.nasa.gov/apod/ap001127.html
Astronomy Picture of the Day
2000 November 27
http://antwrp.gsfc.nasa.gov/apod/astropix.html

Climate changes are already underway in the U.S. too

- Increasing temperature
- Rising sea level
- Rapidly retreating glaciers
- Thawing permafrost
- Longer growing season
- Longer ice-free season in the ocean and on lakes and rivers
- Earlier snowmelt
- Increasingly intense downpours
- Increase in droughts, fires, floods

USGCRP 2009 and draft NCA 2013